

THE UNIVERSITY OF CHICAGO

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OF THE  
YERKES OBSERVATORY

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Physical &  
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## MEASURES OF DOUBLE STARS



## MEASURES OF DOUBLE STARS WITH THE 40-INCH REFRACTOR OF THE YERKES OBSERVATORY IN 1900 AND 1901

S. W. BURNHAM

THE double-star measures recorded here were made principally in the years 1900 and 1901. The observations preceding this period were almost entirely of the  $\beta$  stars; and the mean results have been incorporated in the "General Catalogue of 1290 Double Stars" discovered by the writer from 1871 to 1899, and issued in 1900 as Vol. I of the *Publications of the Yerkes Observatory*. The detailed measures have not been printed, but, as the results have been given in connection with all the measures of these stars, arranged in chronological order, I have not thought it worth while to give the separate observations.

In making the working-list of objects for measurement, the purpose was to include no star likely to be observed elsewhere, and to confine it wholly to long-neglected and little-known pairs, and those which for the lack of sufficient measures, or the uncertainty of the early results, could not be classified as to motion or otherwise. These stars, so far as the early astronomers are concerned, come largely from the several catalogues of the two Herschels and South, with some of the rejected Struve pairs also catalogued and roughly measured by Herschel II. Many of these, and particularly those from Herschel I. and South, are wide pairs, and too widely separated to be considered by modern observers as double stars in the proper sense of the term; and, whenever change has been found in this class of objects, it is very probable that it is due to the proper motion of one or the other of the components. In the other class, where the distances are less, the changes, if confirmed by later observations, may point to physical systems, though, of course, the orbital movement would of necessity be slow. It seemed very desirable that these stars, among the oldest known so far as the literature of the subject is concerned, and observed by the most eminent astronomers who have ever lived, should receive sufficient attention from modern observers to show whether or not in this long interval there has been any relative motion. In many instances the measures now made do not satisfactorily determine this, since the apparent change may be accounted for by errors in the single observations made when the pair was first catalogued, and another series of measures at some later time may be necessary.

It will be seen that in many of these stars there are great apparent changes, and it is practically certain, after making all due allowance for the early observations, that many of these changes are real. The measures of Herschel II. consist usually of a single reading for the position-angle and an estimate of the distance. The angles are generally very accurate, so far as one can judge from the better-known class of stars catalogued by him; but the distances, and particularly those which are under  $10''$ , would seem to be very frequently underrated, so that many of the apparent changes in this respect will probably not prove to be real. The observations were all made seventy or eighty years ago, and, with few exceptions, these pairs have been entirely neglected since that time. A slow movement of any kind would make a decided change in the relation of the components after such an interval of time. Another set of measures twenty or thirty years hence will dispose of the question of motion and eliminate many of these objects with respect to any further attention.

The neglected pairs of Herschel I. and South belong largely to the wider classes, and therefore were not incorporated by Struve in *Mensuræ Micrometricæ*. Some of the pairs of the first observer have not been observed at all since that time, the interval being about a century and a quarter. The measures of South were made about 1825, and the objects taken from his catalogue have either not been measured since at all, or the later measures indicate some change.

Another class of stars selected for measurement has been taken from various star catalogues where

the star was noted as double by the meridian observer. These catalogues include Weisse, Argelander, Harvard Zones, some of the A. G. catalogues, and others. These pairs have not been previously measured. Some of them are likely to prove to be physical pairs.

Some of the neglected O $\Sigma$  stars were put on the list, but on the appearance of Hussey's complete re-observation of all the Poulkova stars (*Publications of the Lick Observatory*, Vol. V) further measures were unnecessary, and this part of the work was discontinued. The wide pairs noted by O $\Sigma$ , which correspond to similar pairs given in Appendices I and II to the *Mensuræ Micrometricæ*, of which there are no measures since the observations of Dembowski, some twenty-five years ago, have been measured to ascertain whether or not there has been any change since that time.

A further class of pairs has been taken from more modern works, which include some of the pairs recorded by the several observers at the Cincinnati and Harvard College Observatories, and others still more recently catalogued. Many of these were given only approximate places and a single measure for the relative position. In all cases the error of place has been corrected, and the object identified in the D. M. or some other star catalogue. In a few instances the pair could not be found at all after a careful search in the vicinity of the assigned place.

The observing-list of stars selected in this way would obviously be a long one, and the work laid out is far from being finished. The observations which follow, amounting to about fifteen hundred measures, include only the pairs which have been measured on at least two nights. Those which have been measured once only must be given in a later series. A large number of pairs are still to be measured for the first time.

The method of making the measures has been too often described to need repeating here, since it is practically the same with all observers who use the micrometer. Double distances have, of course, been taken, and a sufficient number of readings made, usually three to five, to give as good a mean as the observer can attain. From a large number of transits, and measures of difference of declination of well-determined stars, by Professor Barnard and myself, the value of 9.5666 for one revolution of the micrometer has been adopted.

In the course of these observations a few new pairs have been picked up, which are given at the end of the other measures. These are numbered in continuation of my prior lists from 1291 to 1308 inclusive. The reason why this number of new pairs is not larger will be readily understood when it is explained that, in the first place, the finding of new pairs was no part of the work planned, and no time was spent in the examination of adjacent stars; and, in the second place, for all stars smaller than 7.5 magnitude, diagrams were carefully platted to scale from the D. M. catalogues, showing the place of the pair sought and all the other stars in the vicinity, down to the Argelander limit, within a radius of about one degree. This preparation was essential in the interest of saving time in finding the object, and for the purpose of properly identifying it. Hence, except in cases where the given place was erroneous, the proper star could be placed in the field at once without loss of time, and no attention given to the other stars in the neighborhood. With any other plan, doubtless, a large number of new pairs, of more or less apparent interest, would have been found, but necessarily it would have seriously interfered with the carrying out of the arranged program, which would require at least several years thoroughly to complete; and it seemed much more important at this time to correct the descriptions and places of the stars recorded by some of the first observers, and get data for learning something of the movement of these long-neglected pairs. The old and well-known double star systems are in no danger of being overlooked, and there has always been an unnecessary duplication of the measures of these pairs.

The star-places given are for 1880.

## I. MEASURES OF KNOWN DOUBLE STARS

**Σ 3065** *rej.* S.D.(15°)3. 8.6 . . . 8.7R.A. = 0<sup>h</sup> 1<sup>m</sup> 51<sup>s</sup> }  
Decl. = - 14° 54' }

1901.796	289° 2	9.44
.854	289.1	9.55
1901.82	289.1	9.49

No other measures of this pair.

**Σ 3064** *rej.* 7.2 . . . 10.4R.A. = 0<sup>h</sup> 2<sup>m</sup> 10<sup>s</sup> }  
Decl. = + 39° 26' }

1901.722	358° 1	23.91
.796	356.4	23.80
1901.76	357.2	23.85

The only other measures are by H, 351° 1 : 20' ± (1830).

**β Cassiopeiae.** 2 . . . 15R.A. = 0<sup>h</sup> 2<sup>m</sup> 43<sup>s</sup> }  
Decl. = + 58° 29' }

1900.684	204° 5	22.88
.725	204.0	22.44
1900.70	204.2	22.66

The only other measures of the Clark companion are my own in 1889. The principal star has a proper motion of 0.550 in 110°.2. This movement, with the measures of 1889, gives the position of the small star for the date of the above measures, 204° 8 : 22.28. It is therefore certain that the companion is fixed in space.

O.Arg.N.21. 8.8 . . . 8.8

R.A. = 0<sup>h</sup> 2<sup>m</sup> 51<sup>s</sup> }  
Decl. = + 58° 58' }

1901.818	145° 1	23.44
.835	144.6	23.26
1901.82	144.8	23.35

"Duplex" in O.Arg. No other measures. These stars are D.M.(58°)4 and 5. The A.G. positions give 143° 6 : 2.592 (1873.7).

**H 1001.** D.M.(43°)7. 8.5 . . . 9.1R.A. = 0<sup>h</sup> 2<sup>m</sup> 57<sup>s</sup> }  
Decl. = + 44° 3' }

1901.722	77° 5	15.80
.758	77.7	15.72
1901.74	77.6	15.76

The R.A. in H is 1<sup>m</sup> too large. He gives 84° 5 : 13' ±. No other measures.

**H 1939.** 8 . . . 9.3R.A. = 0<sup>h</sup> 3<sup>m</sup> 41<sup>s</sup> }  
Decl. = + 10° 45' }

1901.605	161° 2	34.75
.742	161.3	35.09
1901.67	161.2	34.92

The Decl. in H is 5' too small. By a single measure in 1877 I found 159° 1 : 36.08.

**Σ 3.** *Andromedae* 51R.A. = 0<sup>h</sup> 3<sup>m</sup> 49<sup>s</sup> }  
Decl. = + 45° 43' }

1901.722	83° 4	4.87
.758	83.4	4.79
1901.74	83.4	4.83

H notes another small star, 133° 0 : 4.57, and says: "Possibly the small star is a mere illusion." I could not see anything of it here, or attached to any star in the vicinity. No change in the Σ components.

**Σ 6** *rej.* D.M.(4°)9. 8.9 . . . 10.5R.A. = 0<sup>h</sup> 4<sup>m</sup> 6<sup>s</sup> }  
Decl. = + 4° 13' }

1901.605	192° 8	21.20
.742	192.7	21.02
1901.67	192.7	21.11

The only other measures are by the Harvard observers, 193° 2 : 22.56 (1869.92) 1a.

**H 617.** D.M.(0°)9. 9.2 . . . 12.7R.A. = 0<sup>h</sup> 5<sup>m</sup> 4<sup>s</sup> }  
Decl. = + 0° 36' }

1900.706	61° 8	13.57
0.744	59.2	13.39
1.742	60.9	13.13
1901.06	60.6	13.36

H gives 55° ± : 6' ± : 9 . . . 14, and says "a third 18m at 4° : 32.0 suspected." I could not see any other companion.

**H 618.** D.M.(-0°)17. 9.6...9.6

R.A. = 0° 7' 22" }  
Decl. = - 0° 47' }

1901.742	249.6	5.33
.854	71.4	5.16
1901.80	250.5	5.24

No other measures;  $250^{\circ} \pm 2^{\circ}$  (1820) H.

**H 1947.** 7.3...10.5

R.A. = 0° 10' 3" }  
Decl. = + 42° 58' }

1901.818	75.6	9.14
.835	75.1	9.06
1901.82	75.3	9.10

The principal star (Radcliffe 44) has a small proper motion (*Mon. Not.*, LI, 398).

1879.40 74.6 9.36 2*n* 0*Σ*

**W<sup>2</sup> 0.264.** 8.5...8.5

R.A. = 0° 11' 10" }  
Decl. = + 35° 10' }

1901.835	107.0	5.34
.854	107.6	5.25
1901.84	107.3	5.29

"Duplex 4" distance" in Weisse. The only measure is:

1879.61 106.4 5.35 1*n* C*n*

**H 1951.** S.D.(12°)44. 8.6...12.0

R.A. = 0° 12' 41" }  
Decl. = - 11° 37' }

1901.796	217.9	22.72
.854	217.1	23.03
1901.82	217.5	22.87

The only complete measure preceding this is:

1877.95 216.6 24.00 1*n* β

**H 1953.** *γ Ceti.* 1...12

R.A. = 0° 13' 19" }  
Decl. = - 9° 30' }

1900.666	17.0	63.00
.668	17.1	62.75
1900.66	17.0	62.87

The other measures are:

1880.31 15.5 61.96 2*n* β

The principal star has a very small proper motion, 0.057 in 236.0.

**Hd 17**

R.A. = 0<sup>h</sup> 18<sup>m</sup> 32<sup>s</sup> }  
Decl. = - 0° 37' }

Described in the Harvard observations, *sp*: 10': 8...12. This star is not double, and no such pair found in the vicinity (1901.74).

**0*Σ* 10 rej.** L 581. 6.3...8.9

R.A. = 0<sup>h</sup> 21<sup>m</sup> 16<sup>s</sup> }  
Decl. = + 15° 22' }

1901.742	237.6	100.55
.854	238.0	100.96
.873	237.8	100.97
1901.82	237.8	100.83

The first measure of this distant star is:

1866.68 237.0 96.34 3*n* J

The A.G. proper motion of the principal star is 0.092 in 286.2. The above measures give 0.133, so that the first is too small, or the other star has a movement of its own.

**H 322.** 12 *Ceti.* 6.5...11.7

R.A. = 0<sup>h</sup> 23<sup>m</sup> 55<sup>s</sup> }  
Decl. = - 4° 37' }

1901.760	189.4	9.70
.815	188.4	9.52
.818	188.8	9.40
.835	189.6	9.53
1901.81	189.0	9.54

The only measures are:

1866.76 185.2 8.66 3*n* J  
1880.23 187.0 8.63 3*n* β

The proper motion of A is practically zero.

**β 107**

R.A. = 0<sup>h</sup> 24<sup>m</sup> 31<sup>s</sup> }  
Decl. = + 62° 41' }

A and B

1900.706	354.9	5.71
.725	353.2	5.69
1900.71	354.0	5.70

A and C

1900.706	336.7	46.94
.725	336.7	46.62
1900.71	336.7	46.78

## A and D

1900.706	146°5	50°28
.725	146.6	50.36

1900.71	146.6	50.32
---------	-------	-------

## A and E

1900.706	170°9	113°59
.725	170.8	113.51

1900.71	170.9	113.55
---------	-------	--------

## A and F

1900.706	114°1	150°50
.725	113.7	150.48

1900.71	113.9	150.49
---------	-------	--------

## E and e

1900.725	139°1	8°61	16m
----------	-------	------	-----

(See *Popular Astronomy* for December, 1900.)

**H 1982.** 52 *Piscium*. 6...12

R.A. =  $0^h 26^m 18^s$  }  
Decl. =  $+19^\circ 38'$  }

1900.684	304°2	41°08
----------	-------	-------

.687	304.1	41.28
------	-------	-------

1900.68	304.2	41.18
---------	-------	-------

The only measures are:

1830 +	309°6	25'±	1m	H
1879.99	305.7	38.30	3m	β

The distance would seem to be increasing. The proper motion is very small, 0'012 in 109°3.

**H 1038.** 10.7...10.8

R.A. =  $0^h 29^m 19^s$  }  
Decl. =  $+63^\circ 4'$  }

1901.722	111°0	3°77
----------	-------	------

.818	109.3	3.81
------	-------	------

1901.77	110.1	3.79
---------	-------	------

The only position is by H, 97°0:13' (1828); "in contact with 160; just separated with 240." I looked this up in 1876 with the 6-inch, and estimated the distance as fully 2". Not in D.M.

**H 1040.** 10.9...11.2

R.A. =  $0^h 31^m 37^s$  }  
Decl. =  $+65^\circ 7'$  }

1901.722	355°4	4°88
----------	-------	------

.796	353.3	5.18
------	-------	------

1901.76	354.3	5.03
---------	-------	------

H gives  $356^\circ 4: 2' \pm$  (1830).

**H 3380.**

R.A. =  $0^h 33^m 35^s$  }  
Decl. =  $-17^\circ 23'$  }

H gives  $96^\circ 2: 30' \pm: 7\frac{1}{2} \dots 13$  (1836.78). There is no bright star in this place, and I could not find any such pair in the vicinity. It may be identical with H 2067, which is 1<sup>h</sup> more R.A. The descriptions agree.

D.M. ( $-0^\circ$ ) 75. 7.6...11.5

R.A. =  $0^h 31^m 56^s$  }  
Decl. =  $-1^\circ 10'$  }

1901.703	307°1	30°46
----------	-------	-------

.873	306.5	30.50
------	-------	-------

1901.79	306.8	30.48
---------	-------	-------

This was measured for 253 *rej*. No other observations. The principal star is 6.8m in D.M., and has a proper motion of 0'087 in 253°4.

Σ 53 *rej*. 8.0...8.7

R.A. =  $0^h 37^m 18^s$  }  
Decl. =  $-1^\circ 32'$  }

1901.735	338°9	27°79
----------	-------	-------

.854	338.3	27.61
------	-------	-------

1901.76	338.6	27.70
---------	-------	-------

The earliest measures are:

1891.81	334°6	26°47	3m	Engelhardt
---------	-------	-------	----	------------

This star has a considerable proper motion; 0'415 in 216°6 (Porter); 0'301 in 228°4 (Nico. A.G.). The smaller star is probably not moving with the other.

**H 1051.** 11...13.2

R.A. =  $0^h 38^m 11^s$  }  
Decl. =  $+24^\circ 3'$  }

1900.706	221°0	6°52
----------	-------	------

.780	221.2	6.88
------	-------	------

1900.74	221.1	6.70
---------	-------	------

The distance seems to be greatly overestimated by H, as in nearly every instance of this kind. He gives  $275^\circ 0: 11\frac{1}{2}': 10 \dots 14$  (1828). It is near D.M. (23°) 98.

**H 626.** D.M.(30°) 110. 8.5...11...12.5

R.A. =  $0^h 39^m 7^s$  }  
Decl. =  $+31^\circ 1'$  }

## A and B

1901.703	345°9	32°16
----------	-------	-------

.758	346.4	32.46
------	-------	-------

1901.73	346.1	32.31
---------	-------	-------

# MEASURES OF DOUBLE STARS

## B and C

1901.703	105.8	10.54
.758	107.1	10.16
1901.73	106.4	10.35

H gives  $330^{\circ} \pm 20^{\circ} \pm 9 \dots 14$ ; "large star, very red." The third star was not seen by him. A is only yellowish at most.

## H 1054. D.M.(59°)125. 8.2 ... 10.5

R.A. =  $0^{\text{h}} 42^{\text{m}} 31^{\text{s}}$  /  
Decl. =  $+ 60^{\circ} 6'$  /

1901.796	182.5	8.75
.799	181.6	8.58
1901.80	182.0	8.66

H gives  $176^{\circ} 0' 5'' \pm 9 \dots 13$  (1828).

## Hd 35. S.D.(2°)110. 8.7 ... 9.3

R.A. =  $0^{\text{h}} 42^{\text{m}} 28^{\text{s}}$  /  
Decl. =  $- 2^{\circ} 25'$  /

1901.835	37.1	6.86
.873	37.0	6.99
1901.85	37.0	6.92

From the Harvard list. The only measure is:

1867.89	37.4	7.04	1m	Hd
---------	------	------	----	----

## Hd 36

R.A. =  $0^{\text{h}} 43^{\text{m}} 10^{\text{s}}$  /  
Decl. =  $- 21^{\circ} 48'$  /

This is in the Harvard list as O.Arg.S.439, with the correct place as given above. The description is  $16^{\circ} 6' : 21^{\circ} : 7 \dots$  (1868.82). This star is not a double of any kind, nor is there any pair as described in the vicinity. The nearest pair is  $\beta$ 301, but this does not correspond in any respect to measures or magnitude.

## O $\Sigma$ (App) 9. 8 ... 8.2

R.A. =  $0^{\text{h}} 43^{\text{m}} 21^{\text{s}}$  /  
Decl. =  $- 29^{\circ} 48'$  /

1901.703	236.8	96.72
.799	236.5	96.10
1901.75	236.6	96.41

The principal star has a proper motion of  $0.263$  in  $100^{\circ} 3$  from meridian positions. The measures of  $\Delta$  in 1875 compared with the foregoing give  $0.217$  in

$92^{\circ} 1$ . There is a  $12\text{m}$  star nearly midway, from A  $252^{\circ} 7$  and from B  $42^{\circ} 5$ .

## H 628. 7.7 ... 11.5

R.A. =  $0^{\text{h}} 45^{\text{m}} 25^{\text{s}}$  /  
Decl. =  $+ 33^{\circ} 14'$  /

1901.703	68.5	42.73
.796	68.8	42.51
.799	69.0	42.53
1901.76	68.8	42.59

H gives  $65^{\circ} \pm 35^{\circ} \pm 7 \dots 16$ ; "large star red." The principal star is not red - yellowish at most.

## Weisse

R.A. =  $0^{\text{h}} 45^{\text{m}} 56^{\text{s}}$  /  
Decl. =  $+ 25^{\circ} 8'$  /

"Duplex" in Weisse. Not double except as a wide pair in the finder. There are three observations in Weisse differing slightly in place.

## O.Arg.N.901. 8.5 ... 8.9

R.A. =  $0^{\text{h}} 50^{\text{m}} 3^{\text{s}}$  /  
Decl. =  $+ 59^{\circ} 41'$  /

1901.796	201.9	20.82
.799	202.8	20.64
1901.79	202.3	20.73

"Duplex" in O.Arg. The only measures are  $203^{\circ} 2' : 21^{\circ} 24$  (1892.77) Espin. The components are D.M.  $(59^{\circ}) 150$  and  $149$ .

## $\mu$ Andromedae. 4 ... 13.5 ... 13.2

R.A. =  $0^{\text{h}} 50^{\text{m}} 6^{\text{s}}$  /  
Decl. =  $+ 37^{\circ} 51'$  /

## A and C (- H 1057)

1901.799	122.2	36.87
.818	122.3	36.87
1901.80	122.2	36.87

## A and B

1901.818	310.8	39.82
.835	311.4	39.56
1901.82	311.1	39.69

The large star has a proper motion of  $0.173$  in  $73^{\circ} 2$ .

1878.67	110.9	38.37	3m	$\beta$
1878.67	314.4	37.27	3m	$\beta$

**Winnecke. D.M.(8°)137. 9...9.2**

R.A. =  $0^h 51^m 46^s$  /  
Decl. =  $+ 8^{\circ} 38'$  \

1901.703	128.3	5.40
.760	130.1	5.41
1901.73	129.2	5.40

The only other measures are:

1863.86    130.2    5.32    2*n*    W<sub>II</sub>

**H 2026. D.M.(4°)204. 8.6...11**

R.A. =  $1^h 5^m 42^s$  /  
Decl. =  $+ 4^{\circ} 15'$  \

1900.706	306.6	10.11
.742	306.0	10.34
.782	305.6	10.33
1900.74	306.1	10.26

H gives  $303.3 : 10' \pm : 10 \dots 15$  (1830). The principal star has a considerable proper motion,  $0.214$  in  $215^{\circ}1$  (Porter) and  $0.28$  in  $290^{\circ}8$  (Boss). This would seem to be common to both stars.

 **$\Sigma$  103. S.D.(2°)192. 8.4...9.7**

R.A. =  $1^h 10^m 33^s$  /  
Decl. =  $- 2^{\circ} 10'$  \

1901.703	246.5	5.49
.796	246.7	5.34
1901.75	246.6	5.41

No recent measures, but probably unchanged. Some uncertainty in place heretofore.

**H 5453. D.M.(−1°)167. 8.3...9.9**

R.A. =  $1^h 12^m 29^s$  /  
Decl. =  $- 1^{\circ} 29'$  \

1901.703	208.3	27.56
.796	208.5	27.35
1901.75	208.4	27.45

The positions are estimated by H,  $210^{\circ} : 30''$ . Engelhardt gives  $209.5 : 27.95$  (1891.81) 2*n*. The principal star has a proper motion of  $0.499$  in  $121^{\circ}4$ , and the small star seems to be moving with it.

**Barnard. D.M.(3°)184. 8.5...11**

R.A. =  $1^h 12^m 40^s$  /  
Decl. =  $+ 4^{\circ} 1'$  \

1900.742	12.0	1.45
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Discovered by Barnard. No change since his measures of 1894.

**H 1079. 44 Ceti. 6...10.5**

R.A. =  $1^h 18^m 0^s$  /  
Decl. =  $- 8^{\circ} 38'$  \

1900.725	298.9	80.37
.744	298.5	80.37
1900.73	298.7	80.37

The only observations are:

300.5     $60^{\circ} \pm$     1828    1*n*    H  
299.6    76.40    1877.86    1*n*     $\beta$

The principal star has a proper motion of  $0.134$  in  $115^{\circ}4$ , which accounts for the change in distance.

**H 638. 11.2...11.5**

R.A. =  $1^h 19^m 5^s$  /  
Decl. =  $- 4^{\circ} 47'$  \

1901.760	271.8	9.52
.876	271.3	9.30
1901.82	271.5	9.41

In the field *nf* S.D.(4°)203. The only observation is by H,  $273.0 : 2'-3''$  (1820).

**H 640. S.D.(4°)230. 9.5...9.5**

R.A. =  $1^h 27^m 27^s$  /  
Decl. =  $- 4^{\circ} 8'$  \

1901.760	290.1	5.33
.876	291.3	5.29
1901.81	290.7	5.31

No other measures.

 **$\tau$  Andromedae. 5...10.2**

R.A. =  $1^h 33^m 30^s$  /  
Decl. =  $+ 39^{\circ} 58'$  \

1900.684	329.0	52.53
.706	329.1	52.73
1900.69	329.0	52.63

The only other observations are  $328.4 : 52.35$  (1880.68) 2*n*  $\beta$ . The proper motion of this star is small,  $0.019$  in  $37^{\circ}4$ .

**H 2067. L 3056. 7.2...11.1.**

R.A. =  $1^h 33^m 33^s$  /  
Decl. =  $- 18^{\circ} 24'$  \

1901.760	91.3	34.07
.876	91.9	33.66
1901.81	91.6	33.86

Probably without change. The distance in H of 5" may be a misprint for 25". In my measure of 1878 the distance is printed 23.90 instead of 33.90. The measures of Wilson (Cin<sup>10</sup>) belong to H 3455, which is 4m f this pair.

### H 1088. L 3044. 7.0 ... 9.5

R.A. =  $1^h 31^m 20^s$  /  
Decl. =  $-58^\circ 1'$  /

1900.780	168.0	19.52
1901.796	167.2	19.41
1901.79	167.6	19.46

H gives  $164.5 : 15' \pm$  (1828).

### H 3455. 9.1 ... 9.2

R.A. =  $1^h 37^m 31^s$  /  
Decl. =  $-18^\circ 13'$  /

1901.760	74.5	23.56
.876	73.6	23.73
1901.81	74.0	23.64

The components are S.D.(18")291 and 292. The only measures are :

1882.70 73.2 23.90 1m Wilson

### $\Sigma$ 168. 8.5 ... 10

R.A. =  $1^h 43^m 6^s$  /  
Decl. =  $+66^\circ 9'$  /

1900.725	224.2	1.73
1901.796	222.6	1.87
1901.76	223.4	1.80

No measures since  $\Delta$  in 1867. No evidence of change. H could not see it, and I failed with the 6-inch 1874.

### Hd 54. D.M.(1")335. 8.6 ... 11.2 ... 11.2

R.A. =  $1^h 41^m 26^s$  /  
Decl. =  $+1^\circ 55'$  /

A and B

1900.706	117.1	4.18
.742	116.7	4.18
1900.72	116.9	4.33

A and C

1900.706	211.8	15.67
.742	211.1	15.42
1900.72	211.4	15.54

The only other measures are by the Harvard observers on one night in 1867. They give for AC, 213.1 :  $11' 26''$  (1867.365).

### $\Sigma$ 188 *rej.* S.S. ... 9.4

R.A. =  $1^h 50^m 47^s$  /  
Decl. =  $+62^\circ 20'$  /

1901.722	238.4	32.54
.796	238.4	32.62
1901.76	238.4	32.58

H describes the components "very red; fine green." The colors are less prominent.

### H 1100. B.A.C. 588. 6.3 ... 10.6

R.A. =  $1^h 50^m 47^s$  /  
Decl. =  $+64^\circ 3'$  /

1901.722	310.4	38.81
.796	310.1	38.83
1901.76	310.2	38.82

H gives  $310.4 : 30' \pm$ . His declination is  $20'$  in error.

### H 3476. L 3731. 6.2 ... 9.8

R.A. =  $1^h 54^m 29^s$  /  
Decl. =  $-9^\circ 6'$  /

1900.706	193.0	62.05
.725	193.6	61.08
.742	192.5	61.77
1900.72	193.0	61.63

H gives  $183.7 : 60' \pm$ . His declination is  $1 s$  of the real place. The principal star is 5.8m in S.D.

### H 647. D.M.(6")319. 8.8 ... 9.3

R.A. =  $1^h 56^m 16^s$  /  
Decl. =  $+7^\circ 6'$  /

1900.706	35.6	26.71
.742	34.3	26.43
.782	35.1	26.60
1900.74	35.0	26.58

Positions estimated by H : "large star deep blood red—a very intense and remarkable color; small star green." The colors are very marked.

### $\Sigma$ 207. D.M.(16")233. 9 ... 10

R.A. =  $1^h 56^m 45^s$  /  
Decl. =  $+17^\circ 4'$  /

1901.873	186.7	11.88
.876	185.0	11.96
1901.87	185.8	11.92

No recent measures, but without change.

**H 2104.** D.M.(52°)500, 501. 8.7 ... 8.8

R.A.  $- 1^h 57^m 9^s$  }  
 Decl.  $- + 52^\circ 27'$  }

1901.722	167.2	30.27
.758	347.0	30.12
1901.74	167.1	30.19

Both R.A. and Decl. erroneous in H. He gives  $166^\circ 4' : 25' \pm$ . Identified as above.

**H V. 102.** 61 *Ceti*. 6 ... 9

R.A.  $- 1^h 57^m 39^s$  }  
 Decl.  $- - 0^\circ 55'$  }

1900.706	193.7	43.07
.725	194.2	43.11
1900.71	194.0	43.09

H in 1873 made two measures of the distance,  $34.50$  and  $37.88$ . The only other measures are my own,  $193.3 : 42.71$  (1877.86). Bossert gives the proper motion  $0.144$  in  $123.7$ .

 **$\Sigma$  211** *rej.*

R.A.  $- 1^h 58^m$  }  
 Decl.  $- - 6^\circ 0'$  }

H could not find any pair in or near this place.  $\Sigma$  gave this as Class IV, 8 ... 11. There is no star in the assumed place. There is a  $7\frac{1}{2}m$  star about  $15's$  with a distant  $9\frac{1}{2}m$  star in the field, which may be the one in question.

 **$\Sigma$  213.** D.M.(50°)459. 8.4 ... 8.6 ... 12.5

R.A.  $- 2^h 1^m 17^s$  }  
 Decl.  $- + 50^\circ 30'$  }

## A and B

1900.782	320.6	1.96
1901.722	323.6	1.81
1901.25	321.8	1.88

## A and C

1900.782	62.8	7.19
1901.722	59.7	6.88
1901.25	61.2	7.03

No recent measures; no sensible change. The third star has not been seen before.

 **$\Sigma$  219.** 8.2 ... 8.7

R.A.  $- 2^h 3^m 11^s$  }  
 Decl.  $- + 32^\circ 48'$  }

1900.742	183.6	11.63
1901.586	183.9	11.49
.818	182.3	11.50
1901.38	183.3	11.54

No recent measures; apparently fixed.

 **$\Sigma$  226.** 8.4 ... 10.2

R.A.  $- 2^h 5^m 27^s$  }  
 Decl.  $- + 23^\circ 24'$  }

1900.706	249.5	2.40
.742	246.2	2.13
1901.818	241.8	2.13
.835	244.8	1.95
1901.27	245.6	2.15

No measures since  $\Delta$ ; little if any change. The Berlin A.G. gives the proper motion of A,  $0.187$  in  $126.0$ , and the small star is therefore moving with it.

**H 1115.** 10 *Trianguli*. 6 ... 12

R.A.  $- 2^h 11^m 59^s$  }  
 Decl.  $- + 28^\circ 5'$  }

1900.742	206.2	57.14
.744	204.5	57.04
1900.74	205.3	57.09

H gives  $206.8 : 50 \pm$ , and calls the small star  $18m$ . No other measures.

 **$\Sigma$  247** *rej.* D.M.(3°)320. 9.0 ... 9.0

R.A.  $- 2^h 12^m 7^s$  }  
 Decl.  $- + 3^\circ 37'$  }

1901.703	211.3	7.61
.876	212.1	7.48
1901.79	211.7	7.54

The only measure is:

1879.66	32.2	7.39	$1m$	Cin
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**H 2134**

R.A.  $- 2^h 16^m 0^s$  }  
 Decl.  $- - 11^\circ 10'$  }

Described by H,  $265.2 : 9 \pm : 9 \dots 10.11$ . There is no pair of this description in or near this place. It is certainly identical with H 2140, which is about  $5m f$ .

**H 649.** 12.5 . . . 13

R.A. =  $2^{\text{h}} 17^{\text{m}} 4^{\text{s}}$   
Decl. =  $+ 9^{\circ} 4'$

1901.799      127.5      9.10

H has 120 :  $1\frac{1}{2}$  : 15 . . . 16.

**H 2140.** S.D. 11 459. 8.5 . . . 10

R.A. =  $2^{\text{h}} 19^{\text{m}} 59^{\text{s}}$   
Decl. =  $- 11^{\circ} 10'$

1901.703      263.4      10.70

.742      263.1      10.51

1901.72      263.2      10.60

In H, "R.A. conjectural." Identified as above. Identical with H 2134, for which H gives  $265^{\circ} 2 : 9' \pm : 9 \dots 10-11$ . The R.A. of that star is also in error.

**O $\Sigma$  (App) 27.** 7.5 . . . 8.5

R.A. =  $2^{\text{h}} 20^{\text{m}} 19^{\text{s}}$   
Decl. =  $+ 10^{\circ} 2'$

1900.706      31.8      73.67

.725      31.9      73.79

1900.71      31.8      73.73

The only other measures are by 4,  $31^{\circ} 2 : 73^{\circ} 6$  (1875.42).

**Hd Zones**

R.A. =  $2^{\text{h}} 29^{\text{m}} 0^{\text{s}}$   
Decl. =  $- 0^{\circ} 37'$

In the Harvard Zones an 8m star noted as "double." The place is that of the 9m star D.M.(0-) E1, but this is not a double of any kind.  $\Sigma$  274 is 4" p, and possibly the note has reference to that pair.

**O.Arg.N. 2946**

R.A. =  $2^{\text{h}} 29^{\text{m}} 29^{\text{s}}$   
Decl. =  $+ 49^{\circ} 44'$

"Duplex" in O.Arg. Not double; there is a 10m star about  $53''$  distant. I failed to find it in 1875.

**H 3518.** O.Arg.S. 1715. 8.6 . . . 10.5 . . . 10.6

R.A. =  $2^{\text{h}} 43^{\text{m}} 38^{\text{s}}$   
Decl. =  $- 28^{\circ} 41'$

**A and B**

1900.742      15.2      13.29

1901.760      15.5      13.87

1901.25      15.3      13.58

**A and C**

1900.742      242.8      14.26

1901.760      243.4      14.12

1901.25      243.1      14.19

H gives  $193^{\circ} 6 : 10' \pm$  and  $299^{\circ} \pm : 12' \pm$ .

**O.Arg.N. 3145.** 8.4 . . . 8.4

R.A. =  $2^{\text{h}} 38^{\text{m}} 46^{\text{s}}$   
Decl. =  $+ 49^{\circ} 37'$

1901.589      143.0      3.08

.758      146.5      3.08

1901.67      144.7      3.08

"Duplex" in O.Arg.N. It is Hussey 204. He gives  $143^{\circ} 4 : 3' 17$  (1900.87) 3n. No other measures. There is a closer pair a little following which I noted many years ago, and in this connection measured it;  $155^{\circ} 5 : 1' 42$  (1901.67) 2n. This is Hussey 205. It is  $57''$  f the other pair, and 3's.

 **$\tau$  Persei**

R.A. =  $2^{\text{h}} 45^{\text{m}} 45^{\text{s}}$   
Decl. =  $+ 52^{\circ} 16'$

**A and B**

1900.684      106.3      50.50

.687      106.7      51.30

.725      107.2      51.09

.742      106.3      50.52

1900.71      106.6      50.85

**B and C**

1900.742      81.7      4.58

The faint star B 12m was first noted by Edgecomb, and in measuring that with the 18 $\frac{1}{2}$ -inch the 13m star C was added. My measures of AB are  $106^{\circ} 4 : 50' 67$  (1878.46) 2n. There is a 14m star from A  $337^{\circ} 3 : 42' 46$  (1900.74) 1n.

 **$\Sigma$  324 rej.** D.M.(46) 658. 6.7 . . . 12.2

R.A. =  $2^{\text{h}} 48^{\text{m}} 27^{\text{s}}$   
Decl. =  $+ 46^{\circ} 41'$

1900.687      203.4      24.94

.725      203.2      25.10

.782      203.5      24.81

1900.73      203.4      24.95

H gives  $191^{\circ} 4 : 12' \pm$  for AB, and  $342^{\circ} 4 : 8' \pm$  for AC. I could see only the star measured, which is B of H. This was rejected by  $\Sigma$  as a close pair.

**H 3543.** Cord.D.M.(29°)1096. 10 ... 10.3 ... 12

R.A. =  $2^h 52^m 30^s$  }  
 Decl. =  $-29^\circ 28'$  }

A and B		
1901.876	264°2	9'89

A and C		
1901.876	69°5	14'39

No measures; described in H, "Triple; Cl. I and II."

**Σ 334**

R.A. =  $2^h 53^m 1^s$  }  
 Decl. =  $+6^\circ 10'$  }

1900.666	316°2	1'45
.668	317.6	1.36
1900.67	316.9	1.40

**H 2170.**  $\gamma$  Persei. ... 11.2

R.A. =  $2^h 56^m 6^s$  }  
 Decl. =  $+53^\circ 2'$  }

1900.684	324°7	57'56
.725	325.0	57.43
.782	324.9	57.32
1900.73	324.9	57.44

H gave the angle  $224^\circ 9$ , probably an error of  $100^\circ$ . The only measures are  $323^\circ 7 : 57^\circ 72$  (1879.55)  $2n \beta$ .

**O.Arg.N. 3418.** 9.0 ... 9.0

R.A. =  $2^h 57^m 34^s$  }  
 Decl. =  $+52^\circ 35'$  }

1901.835	90°1	4'09
.854	90.0	4.19
1901.84	90.1	4.14

"Duplex" in O.Arg. The only measures are:

1900.06	90°2	4'50	$2n$	Espin
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**Σ 353** *rej.* D.M.(17°)494. 9.6 ... 11.0

R.A. =  $3^h 0^m 47^s$  }  
 Decl. =  $+17^\circ 25'$  }

1901.720	59°2	10'70
.799	58.0	10.63
1901.76	58.6	10.66

No other observations except angle of  $56^\circ 4$  by H.

**H V. 117 = Σ 359** *rej.* 7.5 ... 8.5

R.A. =  $3^h 4^m 17^s$  }  
 Decl. =  $+21^\circ 58'$  }

1900.725	320°5	33'39
.744	320.2	32.59
1900.73	320.3	32.99

The only other measures are by H;  $317^\circ 5 : 34^\circ 80$  (1783.65)  $1n$ . The principal star is D.M.(21°)418. There is a nearer companion, 13m,  $267^\circ 0 : 14^\circ 69$  (1900.72)  $1n$ .

**H 3557.** L 6037. 8 ... 10.9

R.A. =  $3^h 9^m 12^s$  }  
 Decl. =  $-14^\circ 53'$  }

1900.706	2°4	27'13
.742	2.2	26.77
1900.72	2.3	26.95

There is an error of  $1^\circ$  in the Decl. of H. The only observations are:

1835.90	$9^\circ 9$	$20^\circ$	$1n$	H
1880.27	5.3	27.13	$3n$	$\beta$

**Σ 371**

R.A. =  $3^h 10^m 23^s$  }  
 Decl. =  $+46^\circ 35'$  }

1900.687	81°7	3'56
.782	82.8	3.14
1901.589	81.1	3.51
1900.76	81.9	3.40

From the measures of  $\Delta$  the angle appeared to be increasing.

1831.20	$74^\circ 7$	$3'35$	$3n$	$\Sigma$
1867.45	81.7	3.32	$3n$	$\Delta$

It would now appear that  $\Sigma$ 's angle was too small, and that the stars are really fixed.

**H 3570.** 7 ... 12

R.A. =  $3^h 16^m 18^s$  }  
 Decl. =  $-20^\circ 45'$  }

1900.706	256°1	33'89
.742	256.0	34.21
1900.72	256.0	34.05

No measures in H; described as "triple or quadruple." No nearer companion than that measured, but other small stars in the field more distant.

**H 2187.** S.D.(11°)652. 8...10.7

R.A. =  $3^h 17^m 32^s$  }  
Decl. =  $-11^\circ 47'$  }

1901.703	240.7	56.04
.742	240.2	56.00
1901.72	240.4	56.02

In one observation H gives for the angle  $239^\circ 5$  (1830), and later  $325^\circ 3$  (1835.9). There is probably an error of  $90^\circ$  in the last. This pair appears to be  $\Sigma$  387 *rej.* Hussey 20 is about  $1^m 40^s$  p, which was measured once,  $235^\circ 4 : 0^\circ 24$  (1901.74).

*Nova Persei*

R.A. =  $3^h 23^m 8^s$  }  
Decl. =  $-43^\circ 30'$  }

Two of the small stars in the field were measured, and then the work discontinued, as it appeared that Aitkin had carefully measured them all.

1901.167	63.4	158.44
.529	63.0	158.41
1901.35	63.2	158.42
1901.167	116.7	102.38
.529	116.4	101.95
1901.35	116.5	102.16

**H IV. 89.** L 6436. 8.1...9.5

R.A. =  $3^h 23^m 35^s$  }  
Decl. =  $+19^\circ 41'$  }

1901.742	147.1	20.35
.796	146.9	20.27
1901.77	147.0	20.31

Porter gives the proper motion of A,  $0.203$  in  $108^\circ 0$ . The components seem to be moving together.

1783.73	152.0	20.05	1 <sup>st</sup>	H
1879.66	147.3	20.40	1 <sup>st</sup>	C'm

 **$\Sigma$  417 *rej.*** S.D.(33°)572. 8.5...9.6

R.A. =  $3^h 27^m 27^s$  }  
Decl. =  $-2^\circ 57'$  }

1901.703	179.5	25.78
.742	179.8	25.78
1901.72	179.6	25.78

The only other position is  $178^\circ 3 : 25^\circ \pm$  (1830) H.

 **$\Sigma$  416 *rej.*** D.M.(19°)556. 8.8...9.7

R.A. =  $3^h 28^m 2^s$  }  
Decl. =  $+19^\circ 24'$  }

1901.720	56.6	26.54
.742	56.5	26.30
1901.73	56.5	26.42

The principal star is catalogued as red. There is a  $11.5m$  star,  $292^\circ 9 : 22^\circ 61$ , previously noted by Espin.

 **$\Sigma$  457.** D.M.(22°)576

R.A. =  $3^h 43^m 15^s$  }  
Decl. =  $+22^\circ 19'$  }

## A and B

1901.815	99.5	1.14
.818	102.0	1.19
1901.81	100.7	1.16

A and C =  $12.6m$ 

1901.815	340.5	18.15
.818	337.1	18.24
1901.81	338.8	18.20

This was observed for the distant star which has not been measured before.  $\Sigma$  mentions it as  $347^\circ : 32'$ . There is no change in the close pair.

**H 666.** L 7069. 6.5...12.7

R.A. =  $3^h 43^m 15^s$  }  
Decl. =  $+9^\circ 3'$  }

1900.684	19.2	30.72
.687	18.3	30.85
1900.68	18.7	30.78

No other measures. H gives  $25^\circ \pm : 25^\circ \pm 6 \dots 17-18$ .

**H 667.** 10.5...12.7

R.A. =  $3^h 44^m 15^s$  }  
Decl. =  $0^\circ 33'$  }

1901.703	89.7	12.64
.758	91.1	12.38
1901.73	90.4	12.52

H gives  $90^\circ \pm : 4^\circ -5^\circ$  AB, and  $300^\circ \pm : 15^\circ$  AC, with magnitudes 9, 12, and 18. I did not see the third star. Not in S.D.

**H 668.** D.M.(-0°)608. 8.5 ... 10.5R.A. =  $3^h 44^m 44^s$  }Decl. =  $-0^{\circ} 32'$  }

1901.703      299.0      21.67

.758      298.1      21.23

1901.73      298.5      21.50

Only H,  $315^{\circ} \pm 18^{\circ} \pm 8 \dots 12$ .**H 3601.** Cord.D.M.(23°)1600. 7.2 ... 9.5R.A. =  $3^h 46^m 31^s$  }Decl. =  $-23^{\circ} 18'$  }

1901.760      300.4      10.62

.796      299.6      10.54

1901.78      300.0      10.58

H found  $303^{\circ} 5' 15'' \pm 8\frac{1}{2} \dots 10$ . No. 33 of the Lowell Catalogue could not be found by Cogshall. It is evidently identical with H 3601, See having an error of  $1^{\circ}$  in its Decl. His measures were  $299^{\circ} 2' 10' 73' 7 \dots 10.8$  (1897.72).

 **$\Sigma$  462.** 5.6 ... 10R.A. =  $3^h 46^m 42^s$  }Decl. =  $-52^{\circ} 1'$  }

1901.720      317.7      8.20

.742      320.7      8.03

1901.73      319.2      8.11

No recent measures, but unchanged. Not in D.M., but near D.M.(51°)804.

**43 Persei.** S 440 = **H** V. 41R.A. =  $3^h 47^m 41^s$  }Decl. =  $+50^{\circ} 21'$  }

1901.720      30.4      75.47

.742      29.9      75.27

.758      30.1      75.36

1901.74      30.1      75.37

The principal star has a proper motion of  $0.155$  in  $147.6$ , which also belongs to the 9.5 companion.

1863.07    29.7    75.15    4u    0Σ

1888.19    30.0    75.34    2u    Engelhardt

There is a 12.5m star nearer than this in  $279'$ .**OS (App) 41.** 7 ... 8.5R.A. =  $3^h 48^m 6^s$  }Decl. =  $+4^{\circ} 49'$  }

1900.684      357.0      58.72

.687      357.3      59.37

1901.854      357.2      58.96

1901.07      357.2      59.02

The only measures are by  $\Delta$  in 1875. There is no change.

**H 3608.**  $\gamma$  Eridani.  $3\frac{1}{2} \dots 13.2$ R.A. =  $3^h 52^m 24^s$  }Decl. =  $-13^{\circ} 51'$  }

1900.706      241.7      52.68

.742      241.5      52.80

1900.72      241.6      52.74

The only other complete measures are my own,  $238^{\circ} 4' 51.93$  (1877.88)  $2u$ . The change in angle is due to the proper motion of A,  $0.114$  in  $158.3$ .

**H N. 93**R.A. =  $3^h 57^m \pm$  }Decl. =  $+23^{\circ} 6' \pm$  }

No measures in **H**; given as Class II; "place extremely precarious." The place agrees with D.M. ( $22^{\circ} 6' 26$ , but that is not double, and has no faint star near it. The pair in question is probably identical with  $\Sigma$  479.

**H 2220.** D.M.(56°)885. 8 ... 11.5R.A. =  $3^h 59^m 49^s$  }Decl. =  $-56^{\circ} 7'$  }

1900.744      296.6      25.63

.763      296.5      25.97

1900.75      296.5      25.80

H gives  $296^{\circ} 4' 14'' \pm 9 \dots 14$  (1830). **$\Sigma$  492 rej.** 6.6 ... 10 ... 10R.A. =  $4^h 0^m 6^s$  }Decl. =  $+41^{\circ} 10'$  }

A and B

1900.687      202.5      94.47

.744      202.2      94.31

1900.71      202.3      94.39

B and C

1900.687      135.7      5.47

.744      135.7      5.74

1900.71      135.7      5.60

In  $\Sigma$  Classes I and VI. No other measures.

**Hd 66.** S.D.(16°)783. 9.6 . . . 9.6

R.A. =  $4^{\text{h}} 1^{\text{m}} 32^{\text{s}}$  }  
Decl. =  $-16^{\circ} 10'$  }

1901.760	83.8	17.73
.796	83.1	17.75
1901.78	83.4	17.74

Given in the Harvard Annals with rough place, and  $261^{\circ}7:18^{\circ}52:9.3 \dots 9.5$  (1868.48) 3*n*. There is a 15*m* star nearer A,  $263^{\circ}4:5^{\circ}68$  (1901.79) 1*n*.

**OΣ 73.**  $\mu$  *Persei*

R.A. =  $4^{\text{h}} 6^{\text{m}} 5^{\text{s}}$  }  
Decl. =  $+48^{\circ} 6'$  }

A and B

1901.720	349.8	14.52
.722	348.5	14.24
1901.72	349.1	14.38

A and C = H VI 20 = Sh 364

1901.720	231.9	84.02
.722	231.6	84.30
1901.72	231.7	84.16

No change in B. For AC Sh found  $231^{\circ}7:91^{\circ}56$  (1822.85) 2*n*. There is a 12.8*m* star nearer than C,  $124^{\circ}2:50^{\circ}36$  (1901.72) 1*n*.

**H 673.** D.M.(30°)641. 9.2 . . . 9.6

R.A. =  $4^{\text{h}} 9^{\text{m}} 25^{\text{s}}$  }  
Decl. =  $+30^{\circ} 30'$  }

1901.799	195.5	21.40
.818	195.8	21.09
1901.81	195.6	21.19

H gives  $210^{\circ} \pm : 18^{\circ} \pm : 7 \dots 10$ . I found many years ago that there was an error in H's magnitude of A. This is given as 9.2 in D.M.

**Σ 519** *v.j.* D.M.(50°)676. 7.7 . . . 9.3

R.A. =  $4^{\text{h}} 11^{\text{m}} 52^{\text{s}}$  }  
Decl. =  $+50^{\circ} 5'$  }

1900.714	346.4	18.29
.763	345.8	17.98
1900.75	346.1	18.13

Given as Class IV in Σ. The only other measures are by Espin,  $346^{\circ}8:18^{\circ}50$  (1892.96) 2*n*.

**OΣ (App) 49.** 7.5 . . . 7.5

R.A. =  $4^{\text{h}} 12^{\text{m}} 41^{\text{s}}$  }  
Decl. =  $+1^{\circ} 29'$  }

1901.742	144.6	102.80
.758	144.8	102.79
1901.75	144.7	102.79

Fixed;  $\Delta$  gives  $144^{\circ}9:102^{\circ}94$  (1875.33) 3*n*. No other measures. These stars are Lalande 8090 and 8093.

**Σ 537.** 8.5 . . . 9.7

R.A. =  $4^{\text{h}} 16^{\text{m}} 21^{\text{s}}$  }  
Decl. =  $-10^{\circ} 14'$  }

1900.706	341.5	16.36
.742	341.6	16.49
1900.72	341.5	16.42

Distance and angle slowly increasing.

1832.39	334.0	14.99	4 <i>n</i>	Σ
1867.10	336.9	15.28	3 <i>n</i>	J
1891.86	340.4	15.98	1 <i>n</i>	β

**β 402**

R.A. =  $4^{\text{h}} 17^{\text{m}} 3^{\text{s}}$  }  
Decl. =  $-1^{\circ} 33'$  }

1901.760	75.3	7.53
.796	73.7	7.52
1901.78	74.5	7.52

This was put on the list in order to observe a third faint star noted by Cogshall at  $110^{\circ}:7^{\circ}8$ , referred to in my General Catalogue. I found a 14*m* star  $111^{\circ}1:29^{\circ}0$ . Since then I have learned from him that there was an error in transcribing the distance, which was really  $29^{\circ}$ , as I found it.

**Σ 530.** D.M.(53°)769

R.A. =  $4^{\text{h}} 17^{\text{m}} 5^{\text{s}}$  }  
Decl. =  $+53^{\circ} 13'$  }

A and B

1901.720	200.5	14.12
.722	200.7	14.19
.742	199.2	14.06
1901.73	200.1	14.12

A and C

1901.742	279.6	36.81
.758	280.3	36.83
1901.75	279.9	36.82

C and D (new). 11.8 . . . 12.0

1901.742	43° 2	1.39
.758	44.4	1.55
1901.75	43.8	1.47

No other measures of C, but it was noted by H in his Fifth Catalogue. This star I found to be a rather difficult pair. The only measures of AB since  $\Sigma$  are by Ma and J. There is no change.

**H 342 = H IV. 117 =  $\Sigma$  539** *rej.* 8.2 . . . 10.2 . . . 12.5

R.A. =  $4^h 17^m 19^s$  }  
Decl. =  $- 5^\circ 17'$  }

A and B

1901.706	234° 8	17.69
.742	235.2	17.35
1901.72	235.0	17.52

A and C

1901.706	82° 5	28° 27
.742	81.8	28.18
1901.72	82.1	28.22

H gave  $238^\circ 2 : 19' 53$  (1783.13) *1n*. No other measures since, except my own in 1877, which show no change as compared with the above.

 **$\Sigma$  541** *rej.* 9.2 . . . 9.3

R.A. =  $4^h 18^m 14^s$  }  
Decl. =  $+ 21^\circ 58'$  }

1900.725	331° 8	5' 22
.744	328.3	5.83
.780	329.5	5.37
1900.75	329.9	5.47

This is the faint pair between  $\kappa^1$  and  $\kappa^2$  *Tauri*. The only other measures are by d,  $327^\circ 2 : 4' 94$  (1874.11) *4n*.

 **$\Sigma$  547.** 8.5 . . . 10.4

R.A. =  $4^h 19^m 48^s$  }  
Decl. =  $- 1^\circ 40'$  }

1901.758	43° 9	2' 04
.796	44.5	1.98
1901.78	44.2	2.01

The change in angle is about  $60^\circ$  since 1831. A comparison of these measures with  $\Sigma$ 's gives  $0' 052$  in the direction of  $316^\circ 1$  for the proper motion of A.

**57 Persei.** Sh 44 = **H VI. 99**

R.A. =  $4^h 24^m 58^s$  }  
Decl. =  $+ 42^\circ 48'$  }

1900.687	198° 8	115° 38
.744	198.4	114.83
.763	198.6	115.46
1900.73	198.6	115.22

The change is due to proper motion, probably of the smaller star. This is given in the A.G. as  $0' 076$  in  $157^\circ 7$ .

1821.91	198° 9	110° 19	1n	Sh
1875.11	198.9	113.68	2n	J

This change in distance corresponds to the movement as given of B.

**H 3653.** O.Arg.S. 3129 and 3130. 8.3 . . . 8.5

R.A. =  $4^h 25^m 7^s$  }  
Decl. =  $- 16^\circ 43'$  }

1900.742	156° 3	42° 58
1901.758	157.4	42.42
1901.75	156.8	42.50

The only other measures are  $148^\circ 5 : 40' \pm$  (1835.9) H. The O.Arg. places give  $155^\circ 9 : 48' 87$  (1850 $\pm$ ).

**Hd Zones.** 10.7 . . . 12

R.A. =  $4^h 26^m 11^s$  }  
Decl. =  $+ 1^\circ 2'$  }

1900.742	235° 8	1' 93
1901.796	239.2	2.42
1901.77	237.5	2.17

Marked "elongated" in the Harvard Zones. No other observations.

**S 451 = O2 (App) 51.** 7.3 . . . 7.7

R.A. =  $4^h 27^m 25^s$  }  
Decl. =  $+ 47^\circ 7'$  }

1900.687	198° 4	58° 68
.744	198.1	58.62
1900.71	198.2	58.65

Probably unchanged.

1875.13	197° 4	59° 27	2n	J
1875.3	198.4	59.44		A.G.

**H 344. D.M.(33°)883. 8.4 ... 11**

R.A. = 4 <sup>h</sup> 28 <sup>m</sup> 26 <sup>s</sup> }		
Decl. = + 33° 41' }		
1900.744	102.0	11.20
.780	102.4	11.14
1900.76	102.2	11.17

The only observations are by H,  $95^\circ \pm 10' \pm 10$   
 .. 14. There is a 14m star  $82^\circ 2' : 17.55$ .

**Σ 565**

R.A. = 4 <sup>h</sup> 29 <sup>m</sup> 42 <sup>s</sup> }		
Decl. = + 41° 53' }		
1900.780	174.3	1.63
.782	173.3	1.48
1900.78	173.8	1.55

Probably fixed. Measured in looking for the  
 Weisse pair given below.

**β 1043. 3 *Camelopardali***

R.A. = 4 <sup>h</sup> 30 <sup>m</sup> 28 <sup>s</sup> }		
Decl. = + 52° 50' }		
1900.687	290.1	3.66
.780	295.8	3.73
.782	292.6	3.74
1901.796	294.3	3.55
.815	297.2	3.88
.818	295.2	3.83
1901.28	295.7	3.73

**Weisse IV. 647. 9 ... 9.1**

R.A. = 4 <sup>h</sup> 31 <sup>m</sup> 42 <sup>s</sup> }		
Decl. = + 42° 6' }		
1901.720	110.3	2.46
.722	113.8	2.44
1901.72	112.0	2.45

Weisse IV 643 is noted "duplex 3" in that cata-  
 logue. That star is not double, and the note doubt-  
 less belongs to the one given here, which is about  
 5 s. No other measures.

**H 346 B.A.C 1444. 6.1 ... 11.0**

R.A. = 4 <sup>h</sup> 33 <sup>m</sup> 49 <sup>s</sup> }		
Decl. = + 28° 23' }		
1901.742	54.5	43.37
.758	54.7	43.27
1901.75	54.6	43.32

No other measures; only estimates by H.

**Σ 579. 8.6 ... 9.7**

R.A. = 4 <sup>h</sup> 34 <sup>m</sup> 32 <sup>s</sup> }		
Decl. = + 22° 30' }		
1901.758	34.5	16.31
.799	34.7	16.43
1901.78	34.6	16.37

No recent measures. No material change.

**S 455. *τ Tauri***

R.A. = 4 <sup>h</sup> 35 <sup>m</sup> 2 <sup>s</sup> }		
Decl. = + 22° 44' }		
1900.684	213.2	63.02
.687	213.1	62.94
1900.68	213.1	62.98

Without change,  $\Delta$  gives  $212^\circ 4' : 62.85$  (1875.35)  
 2n. Large star supposed to be a close pair from an  
 occultation observed by Hough (A.J. 474). Condi-  
 tions too unfavorable at the time of my measures to  
 detect a very close pair.

**Σ 585. D.M.(4°)733. 8.6 ... 10.5**

R.A. = 4 <sup>h</sup> 36 <sup>m</sup> 21 <sup>s</sup> }		
Decl. = + 4° 29' }		
1900.706	275.7	11.85
.742	275.9	12.05
1900.72	275.8	11.95

No recent measures, but unchanged. Place here-  
 tofore approximate; identified as above. The mag-  
 nitude of A in D.M. is 9.2;  $\Sigma$  gives 8.3.

**Hall. D.M.(1°)809. 9.1 ... 9.1**

R.A. = 4 <sup>h</sup> 37 <sup>m</sup> 53 <sup>s</sup> }		
Decl. = + 1° 51' }		
1901.742	157.3	2.35
.758	155.8	2.37
.760	156.1	2.53
1901.75	156.4	2.42

Identified as above. The only other measures are  
 by Hall,  $157^\circ 4' : 2.29$  (1888.10) 3n.

**D.M.(21°)694. 9.1 ... 10.5**

R.A. = 4 <sup>h</sup> 38 <sup>m</sup> 51 <sup>s</sup> }		
Decl. = + 21° 3' }		
1901.758	114.7	5.44
.799	113.8	5.37
1901.78	114.2	5.40

This was measured in trying to find  $\Sigma$  593 *rej.*, which should be about  $1^m 7$  and  $10^m n$ .  $\Sigma$  gave Class IV and magnitudes 8.9...8.9. There is no such star in this place. The 8m star some distance *sf* has a very distant 11m star in  $103^\circ$ , but neither that nor the one measured is likely to be the  $\Sigma$  star.

**H 350.** 11...11

R.A. =  $4^h 43^m 18^s$  }  
Decl. =  $+ 34^\circ 35'$  }

1901.799	308.3	5.32
.818	308.2	4.96
1900.81	308.2	5.14

H describes it as "extremely delicate and beautiful," and gives  $310^\circ \pm 2^\circ \pm$ . It is in the field with D.M.(34°)914.

**H VI. 83.** D.M.(6°)765. 7...8.5

R.A. =  $4^h 44^m 12^s$  }  
Decl. =  $+ 6^\circ 37'$  }

1900.684	4.1	96.08
.742	3.7	95.78
1900.71	3.9	95.93

The only other measure is by **M**, 1.7:80.97 (1783.79) 1*n*.

**S 457.** 8.3...8.3

R.A. =  $4^h 46^m 59^s$  }  
Decl. =  $- 1^\circ 28'$  }

1900.763	354.5	41.03
.780	354.5	41.01
1901.758	354.6	40.96
1901.10	354.5	41.00

No other measures except S, 353.7:41.49 (1824.42) 3*n*. These stars are D.M.(−1°)744 and 743.

**H 3705.** O.Arg.S. 3514. 7.7...10.5

R.A. =  $4^h 51^m 24^s$  }  
Decl. =  $- 16^\circ 19'$  }

1901.758	141.7	22.62
.796	140.8	22.14
1901.78	141.2	22.38

The only other measures are:

1835.9	139.3	$16^\circ \pm$	1 <i>n</i>	H
1880.4	141.0	22.29	3 <i>n</i>	$\beta$

**H 689.** L 9355. 7.5...11.3

R.A. =  $4^h 52^m 8^s$  }  
Decl. =  $- 2^\circ 24'$  }

1901.758	277.6	20.76
.760	279.3	21.18
1901.76	278.4	20.97

The only other measures are 275.6:20.67 (1880.63) 2*n*  $\beta$ .

**W<sup>1</sup> IV. 1215.** 9...9

R.A. =  $4^h 56^m 5^s$  }  
Decl. =  $+ 13^\circ 11'$  }

1900.744	83.0	4.38
.763	84.0	4.39
1900.75	83.5	4.38

"Duplex" in Weisse. The only other measures are in Leipsic A.G., p. 207, 82.2:4.59 (1893.79) 1*n*.

**H 2247.** S.D.(5°)1135. 8.5...11.9

R.A. =  $4^h 56^m 51^s$  }  
Decl. =  $- 5^\circ 53'$  }

A and B

1901.758	58.2	20.91
.796	55.7	20.67
1901.77	57.0	20.79

A and C

1901.758	18.7	33.18
.796	17.1	33.42
1901.77	17.9	33.30

C and D (11.6...13)

1901.758	313.5	2.67
.796	315.2	3.26
1901.77	314.3	2.96

No other measures. H gives 55.6 for AB. The closer star is new.

**OΣ 94** *rej.* O.Arg.N. 5495. 7.5...11...11.3

R.A. =  $4^h 58^m 7^s$  }  
Decl. =  $+ 50^\circ 8'$  }

A and B

1900.744	304.3	17.90
.763	304.0	18.17
1900.75	304.1	18.03

A and C		
1900.744	63.7	25.14
.763	62.6	24.95
1900.75	63.1	25.04

There is a 14m star from A, 340°9: 26'1.

**Σ 640.** (= H 356)

R.A. = 4<sup>h</sup> 59<sup>m</sup> 41<sup>s</sup> }  
Decl. = 33° 15' }

A and B		
1900.725	96.9	9.52
.763	96.3	9.44
1900.74	96.6	9.48

A and C (C = 11m)

1900.725	315.6	25.26
.763	317.0	25.30
1900.74	316.3	25.28

C not in Σ; first noted by H; not measured before. No recent measures of AB, but without change.

**S 466** (= H VI. 105). 105 *Tauri*

R.A. = 5<sup>h</sup> 0<sup>m</sup> 45<sup>s</sup> }  
Decl. = + 21° 33' }

1900.725	250.8	111.45
.763	250.3	111.29
1900.74	250.5	111.37

Both stars have meridian positions. No measures except S.

1825.04	251.0	109.99	2n S
1825 =	251.2	116.33	Weisse
1875 =	250.7	110.44	A.G. Berlin

The proper motion of A is very small, 0.025 in 276.8.

**Edgcomb.** 103 *Tauri*. 6...13

R.A. = 5<sup>h</sup> 0<sup>m</sup> 48<sup>s</sup> }  
Decl. = 21° 6' }

A and B		
1900.725	147.0	13.02
.763	152.3	13.57
1900.74	149.6	13.30

A and C (= H V. 114)

1900.725	138.0	35.52
.763	197.4	35.50
1900.74	197.7	35.51

The faint star B was detected by Edgcomb in 1878. The only measures are 147°9: 12'94 (1878.98) 1n β; and for the other, 197°6: 30'05 (1783.80) 1n by M.

**Σ 642 rej.** 66 *Eridani*. 6...9.7

R.A. = 5<sup>h</sup> 0<sup>m</sup> 48<sup>s</sup> }  
Decl. = - 4° 49' }

1900.763	9.3	52.85
.780	10.0	52.77
1900.77	9.6	52.81

The only other measures are my own, 9°4: 52'50 (1879.95) 2n.

**S 468** (= Σ 650 rej.). 8...8.1

R.A. = 5<sup>h</sup> 3<sup>m</sup> 27<sup>s</sup> }  
Decl. = + 13° 51' }

1900.744	165.4	26.25
.763	165.8	26.45
1900.75	165.6	26.35

No measures since South, 162°6: 27'18 (1825.00) 2n. The A.G. positions give 164°4: 26'68.

**OS 517**

R.A. = 5<sup>h</sup> 7<sup>m</sup> 18<sup>s</sup> }  
Decl. = + 1° 49' }

A and B

1900.780	308.9	0.19
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AB and C (C = 12.2)

1900.780	137.3	6.88
1901.815	139.2	6.72
1901.30	138.2	6.80

The faint star discovered by Hall. Unchanged.

**OS 102**

R.A. = 5<sup>h</sup> 7<sup>m</sup> 18<sup>s</sup> }  
Decl. = + 0° 25' }

Certainly round, with all powers, with good conditions 1900.78. It has not been seen otherwise in the last thirty years. It is probably not a double star.

**W<sup>2</sup> V. 199** = D.M.(31°)913

R.A. = 5<sup>h</sup> 9<sup>m</sup> 31<sup>s</sup> }  
Decl. = + 31° 8' }

Noted as "duplex" in Weisse. It is not a double star of any kind (1901.79). There is a 4 pair of 12m stars in the field.

**$\lambda$  Aurigae.** AD = H V. 22

R.A. =  $5^h 10^m 42^s$  }  
 Decl. =  $+ 39^\circ 59'$  }

A and B (B = 13.5)

1900.780	273.4	28.92
.782	275.4	29.30
1900.78	274.4	29.11

A and C (C = 12.2)

1900.780	224.4	33.57
.782	225.0	34.09
1901.586	225.5	33.83
1901.05	225.0	33.83

A and D (=  $\Sigma$  3 App 11)

1900.780	7.2	133.64
.782	7.2	133.38
1900.78	7.2	133.51

The nearest star has not been seen before. C was added by me with the 18 $\frac{1}{2}$ -in. The measures now show that this star is not moving with A; the only measures are 197 $^{\circ}$ 6:40.47 (1879.28) 2n  $\beta$ . The change is due to the proper motion of A, as is that in the old companion D. The large star has a proper motion of 0.838 in 141 $^{\circ}$ 9. A comparison of my measures with those of  $\Sigma$  in 1836 gives 0.856 in 140 $^{\circ}$ 6.

**H V. 88.** D.M.(39 $^{\circ}$ )1250. 9...10

R.A. =  $5^h 10^m 46^s$  }  
 Decl. =  $+ 40^\circ 0'$  }

1900.782	217.8	32.43
1901.586	217.3	32.46
1901.18	217.5	32.44

Near  $\lambda$  Aurigae. No measures since **H**. 215 $^{\circ}$ 9:35.25 (1783.49) 1n. There are two faint stars between.

**W $^{\circ}$  V. 269.** 8.9...9.0

R.A. =  $5^h 11^m 43^s$  }  
 Decl. =  $+ 36^\circ 5'$  }

A and B

1900.782	329.8	2.85
1901.722	329.6	2.81
1901.25	329.7	2.83

A and C (C = 13.5)

1900.782	224.0	9.88
1901.722	225.3	10.36
1901.25	224.8	10.12

Noted in Weisse "duplex 3 $^{\circ}$ ." No other measures.

**H 3272.** 8...11.5...11.1

R.A. =  $5^h 11^m 48^s$  }  
 Decl. =  $+ 39^\circ 14'$  }

A and B

1900.782	342.1	19.40
1901.720	342.0	19.48
1901.25	342.0	19.44

A and C

1900.782	295.5	29.26
1901.720	295.0	29.06
1901.25	295.2	29.16

A and D

1900.782	42.4	33.13
1901.605	42.5	33.71
.720	41.9	33.25
1901.40	42.3	33.36

The only measures are mine of 1879, which show no change.

**Aitken 53.** S.D.(3 $^{\circ}$ )1061. 8.3...11.2

R.A. =  $5^h 13^m 46^s$  }  
 Decl. =  $- 3^\circ 12'$  }

1900.742	48.3	5.13
.763	47.2	5.13
1901.873	46.9	4.96
1901.12	47.5	5.07

This star has a large proper motion, 0.690 in 77 $^{\circ}$ 5, and the companion is moving with it.

**H 697.** B.A.C. 1657. 6.8...11.7

R.A. =  $5^h 15^m 24^s$  }  
 Decl. =  $0^\circ 32'$  }

A and B

1900.763	59.8	33.06
1901.838	59.8	33.10
1901.30	59.8	33.08

A and C (C = 11.2)

1900.763	110.8	38.60
1901.838	112.2	38.28
1901.30	111.5	38.44

The only other measures are:

1878.99	59.8	32.40	1n	$\beta$
1878.99	109.8	36.81	1n	$\beta$





**$\Sigma$  771.** D.M.(19)1026. 9.0 ... 9.2R.A. = 5<sup>h</sup> 34<sup>m</sup> 42<sup>s</sup> /  
Decl. = 19° 29' /

1901.838 55.2 24.29

.876 55.3 24.00

1901.85 55.2 24.14

The motion is rectilinear. It was put on the list more particularly for identification. In looking for this, a similar pair 7'n and 4'f was measured:

1901.85 342.5 29.25 8.9 ... 10.4 2n

This is D.M.(19)1027.

**29 Camelop.** H IV. 125 = H 2278R.A. 5<sup>h</sup> 40<sup>m</sup> 19<sup>s</sup> /  
Decl. = +56° 53' /

1900.780 130.7 24.84

.782 130.8 24.95

1900.78 130.7 24.90

H found 137.6; 22.43 (1783.50) 1n. The proper motion is small, 0.027 in 244.0.

D.M.(12)901. 8.1 ... 13

R.A. 5<sup>h</sup> 41<sup>m</sup> 15<sup>s</sup> /  
Decl. 12° 1' /

1900.744 339.1 9.19

.763 338.2 10.02

1901.873 340.3 9.15

1901.13 339.2 9.45

Measured in looking for H 5465, which should be about 1-1/2.

 **$\beta$  561.** L 10969. 7.4 ... 13R.A. 5<sup>h</sup> 41<sup>m</sup> 18<sup>s</sup> /  
Decl. = 4° 12' 22" /

1900.744 330 19.17

.763 2.8 18.93

1901.873 3.3 19.02

1901.13 3.0 19.04

Measured in looking for H 5465.

**S 500.** L 10961 and 10963. 8.5 ... 8.5R.A. 5<sup>h</sup> 41<sup>m</sup> 53<sup>s</sup> /  
Decl. = 32° 56' /

1901.796 89.3 59.99

.799 89.2 59.95

1901.79 89.2 59.97

No other measures except S.8839; 59.46 (1825.06) 3n.

**H 5465**R.A. = 5<sup>h</sup> 42<sup>m</sup> 5<sup>s</sup> /  
Decl. = +11° 57' /

The description in H is 45"  $\pm$  12"  $\pm$  7 ... (1823): "An excessively minute companion suspected." I looked for it with the 6-in., 1873-74, and with the 18 $\frac{1}{2}$ -in., 1878, without success; and there is no companion visible in the 40-in. on two nights, 1900-1. The place in H is that of the 7.5m star, D.M.(11)945.

 **$\Sigma$  798.** 7 ... 9.5R.A. = 5<sup>h</sup> 42<sup>m</sup> 25<sup>s</sup> /  
Decl. = 8° 25' /

1900.763 180.9 20.94

.780 181.1 20.87

1900.77 181.0 20.90

No measures since 4, who suspected a 10" companion. There is nothing nearer than the  $\Sigma$  star. Unchanged.

**56 Orionis.** 5 ... 13.5R.A. = 5<sup>h</sup> 46<sup>m</sup> 43<sup>s</sup> /  
Decl. = +1° 49' /

1901.873 212.5 43.45

.876 211.1 43.37

1901.87 211.8 43.41

Taken by mistake for 59 Orionis. There are no other measures.

**Anderson.** L 11231. 7.8 ... 10.4R.A. = 5<sup>h</sup> 49<sup>m</sup> 18<sup>s</sup> /  
Decl. = -19° 44' /

1900.780 20.5 9.26

1901.873 20.0 9.02

1901.32 20.2 9.44

Given in Hall's observations as discovered by Geo. Anderson with the 26-inch. The place is in error by about 2" R.A. and 16" Decl. The only measures are:

1876.09 19.4 9.10 2n Hall

**H 5466.** D.M.(-1)1075.R.A. = 5<sup>h</sup> 51<sup>m</sup> 38<sup>s</sup> /  
Decl. = 1° 50' /

Given in H as 8m, with the note: "seen double, but not verified by magnifying." The place is that of the 9.2m star given here. The 40-in. shows a 14m companion, 110.7, 16.4 (1901.79).

**H V. 100.** 59 *Orionis*. . . . 9.7

R.A. =  $5^h 52^m 10^s$   $\frac{1}{2}$   
Decl. =  $+ 1^\circ 49'$   $\frac{1}{2}$

1900.780	204.3	36.76
1901.876	204.4	36.73
1901.32	204.3	36.74

The proper motion is very small, 0.015 in 136.3.  
The only measures are:

1783.02	205.2	37.25	1 <i>n</i>	<b>H</b>
1878.18	205.8	36.57	1 <i>n</i>	$\beta$

 **$\Sigma$  829.** 8.9 . . . 10.2 . . . 10.4

R.A. =  $5^h 54^m 0^s$   $\frac{1}{2}$   
Decl. =  $- 11^\circ 42'$   $\frac{1}{2}$

A and B

1900.763	235.5	17.69
.780	235.8	17.93
1900.77	235.6	17.81

B and C

1900.763	220.1	5.60
.780	220.7	5.29
1900.77	220.4	5.44

$\Delta$  could not see the smaller star.  $\Sigma$  found 217.7 :  
4.56 (1832.69) 2*n* and 238.4 : 16.50 for AB, which  
indicate some change.

 **$\Sigma$  861**

R.A. =  $6^h 3^m 36^s$   $\frac{1}{2}$   
Decl. =  $+ 30^\circ 42'$   $\frac{1}{2}$

A and B

1900.780	17.3	64.92
1901.720	17.1	65.79
.722	16.7	65.60
1901.41	17.0	65.47

B and C

1900.780	138.4	1.65
1901.720	138.1	1.58
1901.25	138.2	1.61

No change in BC, but the distance of A is slowly  
decreasing. Seabroke thought the principal star was  
a 0.5 pair. It appears now perfectly round.

**H VI. 72.** 68 *Orionis*. B = 8.6

R.A. =  $6^h 4^m 55^s$   $\frac{1}{2}$   
Decl. =  $+ 19^\circ 49'$   $\frac{1}{2}$

1900.744	214.9	85.52
.780	213.7	85.56
1900.76	213.8	85.54

No measures in the last century.

1783.79    229.0    72.83    1*n*    **H**

The small star appears to be D.M.(19°)1252. The  
proper motion of A is small, 0.020 in 95.8.

**H 2302.** 71 *Orionis*

R.A. =  $6^h 7^m 46^s$   $\frac{1}{2}$   
Decl. =  $+ 19^\circ 12'$   $\frac{1}{2}$

1900.744	203.1	29.20
.780	202.4	29.38
1900.76	202.7	29.29

H estimated the positions. The only measures  
are by Engelhardt, 202.4 : 31.98(1886.21)2*n*. The  
change is due to the proper motion of A, 0.203 in  
213.3.

**H 2315.** 11.7 . . . 11.7

R.A. =  $6^h 15^m 6^s$   $\frac{1}{2}$   
Decl. =  $- 7^\circ 14'$   $\frac{1}{2}$

1901.796	3.1	6.37
.873	2.1	6.36
1901.83	2.6	6.36

Given by H,  $3.0 : 1.7 \pm .13 = 13$  (1830), but the  
distance may be underestimated. It is S.D.(7°)1384  
given as 10*m*. In looking for this, a very close pair  
was found about 1*p* and 2*n*. This is the 8*m* star,  
L 12112.

**S 529.** W<sup>1</sup> VI. 883. 7 . . . 8 . . . 7.2

R.A. =  $6^h 30^m 51^s$   $\frac{1}{2}$   
Decl. =  $+ 12^\circ 17'$   $\frac{1}{2}$

A and B

1901.815	153.8	73.85
.838	154.6	74.11
1901.82	154.2	73.98

A and C

1901.815	169.1	167.99
.838	169.2	168.32
1901.82	169.1	168.15

No measures since South in 1825.12; 162.9 : 91.99  
and 170.7 : 187.91. This change is explained by  
the proper motion of A of 0.289 in 194.7. B is a  
red star.

**OΣ 154.** L 12831. 6.4...8.5

R.A. = 6<sup>h</sup> 35<sup>m</sup> 52<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 40° 45'  $\frac{1}{2}$

1900.782	123.6	26.07
1901.720	123.3	26.15
1901.25	123.4	26.11

Rectilinear motion.

**ε Geminae.** H VI. 73 S 533. B = 9.5

R.A. = 6<sup>h</sup> 36<sup>m</sup> 33<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 25° 15'  $\frac{1}{2}$

1900.782	94.1	110.41
1901.818	93.9	110.49
1901.30	94.0	110.45

No measures since South, 93°7 : 111°58 (1825.04)  
2n. The proper motion is very small, 0.025 in 258°.4,  
which should give an increasing distance.

**Σ 967 rej.** S.D.(5°)1797. 8.2...10.5

R.A. = 6<sup>h</sup> 40<sup>m</sup> 25<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 6° 0'  $\frac{1}{2}$

1900.763	189.9	13.22
.780	191.7	13.36
1900.77	190.8	13.29

The only measures are from the introduction to  
*Mens. Mic.*, 191°5 : 11°5 (1832.2) Σ.

**H 740.** 8.2...8.7...11.7

R.A. = 6<sup>h</sup> 45<sup>m</sup> 38<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 0° 36'  $\frac{1}{2}$

A and B

1900.763	8.0	21.03
1901.167	8.0	20.93
1900.96	8.0	20.98

B and C

1900.763	281.4	8.72
1901.167	282.1	8.42
1900.96	281.7	8.57

The only measures are:

1880.50	8.0	20.84	4n	β
1880.60	283.8	8.18	2n	β

**H 748.** S.D.(8°)1706. 8.4...10.5...11.5

R.A. = 6<sup>h</sup> 57<sup>m</sup> 12<sup>s</sup>  $\frac{1}{2}$   
Decl. = - 8° 10'  $\frac{1}{2}$

A and B

1901.796	170.6	6.79
.873	171.9	6.91
1901.83	171.2	6.85

A and C

1901.796	356.9	15.29
.873	358.1	15.21
1901.83	357.5	15.25

In Messier 50. H gave the angles 170°4 and 0°5  
(1820).

**OΣ 164 rej.** L 13675. 7.3...11.2

R.A. = 6<sup>h</sup> 58<sup>m</sup> 20<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 25° 3'  $\frac{1}{2}$

1900.782	50.6	13.80
1901.818	49.9	13.51
1901.30	50.2	13.65

At this time there were no published measures in  
the last fifty years. Madler's distance in 1843 is  
9.09. Hussey's measures in 1899 agree with mine.

**Σ 1033**

R.A. = 7<sup>h</sup> 5<sup>m</sup> 19<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 52° 45'  $\frac{1}{2}$

A and B

1901.799	281.8	1.64
.835	274.4	1.82
1901.82	278.1	1.73

A and C

1901.799	271.9	80.02
.835	271.4	79.29
1901.82	271.6	79.65

C is not in Σ. No change in AB.

1783.06	266.3	67.77	1n	H
1880.53	271.7	78.80	2n	Ball

**OΣ 168 rej.** L 13937

R.A. = 7<sup>h</sup> 5<sup>m</sup> 19<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 21° 33'  $\frac{1}{2}$

A and B

1900.782	66.3	24.20
1901.167	67.2	23.78
1900.97	66.7	23.99

## A and C

1900.782	114°.3	51°.97
1901.167	114.3	51.70
1900.97	114.3	51.83

At this time no published measures since 1868. From his measures, compared with those of  $\Delta$ , Hussey finds for the proper motion of A, 0.047 in 126.6.

**W<sup>2</sup> VII. 118.** 8.2 . . . 8.7

R.A. =  $7^h 5^m 58^s$  }  
Decl. =  $+15^\circ 23'$  }

1901.167	157.0	2.16
.818	157.3	2.27
1901.49	157.1	2.21

In Weisse "duplex 2." No other measures. The magnitude in D.M. is 7.5.

**H 2372.** D.M.(20°)1768. 8.1 . . . 12.5

R.A. =  $7^h 12^m 43^s$  }  
Decl. =  $+20^\circ 41'$  }

1901.818	2.3	22.45
.876	3.3	22.34
1901.84	2.8	22.39

No other measures.

**S 546.** 8.5 . . . 8.6 . . . 8.6

R.A. =  $7^h 13^m 4^s$  }  
Decl. =  $+31^\circ 42'$  }

## A and B

1901.720	358°.8	82°.98
.818	358.6	82.88
1901.77	358.7	82.93

## A and C

1901.720	68°.0	143°.94
.818	68.1	144.14
1901.77	68.0	144.04

The only other measures are :

1825.12	359°.4	79°.60	2 <i>n</i>	S
1825.11	69.2	142.64	1 <i>n</i>	S

These stars are D.M.(31°)1540, 1541, and 1543. There are faint stars between AB and AC.

## D.M.(20°)1775. 6 . . . 13

R.A. =  $7^h 14^m 52^s$  }  
Decl. =  $+20^\circ 40'$  }

## A and B

1900.782	205°.1	17°.62
1901.818	205.1	17.89
1901.08	205.1	17.75

## B and C

1900.782	245°.2	77.73
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Taken at first for H 1775. The principal star has a proper motion of 0.075 in 263.9.

**H V. 66 = S 548.** 6.9 . . . 12.2 . . . 8.4

R.A. =  $7^h 20^m 31^s$  }  
Decl. =  $+22^\circ 23'$  }

## A and B

1901.203	19°.6	11°.52
.876	18.6	11.38
1901.54	19.1	11.45

## A and C

1901.203	276°.4	35°.32
.876	276.2	35.29
1901.54	276.3	35.30

No material change in the bright stars. The only prior measure of B is by Espin in 1892. C is distinctly greenish.

**H V. 63 = Sh 368.** 63 *Geminorum*

R.A. =  $7^h 20^m 37^s$  }  
Decl. =  $+21^\circ 42'$  }

1900.782	323°.2	42°.77
1901.203	323.0	42.91
1900.99	323.1	42.84

The large star has a proper motion of 0.122 in 214.1 (Berlin A.G.). **H** made the distance 44.25 (1785), and Sh the angle 326.2 (1826). The only complete measures are :

1863.2	324.3	44.61	Radcliffe
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 **$\gamma$  Canis Minoris.** . . . 13.0

R.A. =  $7^h 21^m 38^s$  }  
Decl. =  $+9^\circ 10'$  }

1901.203	240°.2	31°.28
.873	241.5	31.47
.878	243.6	31.22
1901.65	241.8	31.32

The only measures are :

1836.19	247.3	34.62	1 <sup>u</sup>	Lamont
1878.06	243.2	32.60	1 <sup>u</sup>	3

The large star has a proper motion of 0.0093 in 286.9, and the change shown by the measures corresponds to this movement.

### S 550. 6.8 ... 7.1

R.A.	= 7 <sup>h</sup> 22 <sup>m</sup> 15 <sup>s</sup> }
Decl.	= - 18° 15' }

1901.167	115.8	39.54
.206	116.1	39.55
1901.18	115.9	39.54

The only other measures are by S, 116° 2 : 40.04 (1825.03) 2<sup>u</sup>. These stars are L 15459 and 15460, the positions giving 112° 9 : 38.65 (1800).

### Σ 1101. 9 ... 9.1

R.A.	= 7 <sup>h</sup> 23 <sup>m</sup> 11 <sup>s</sup> }
Decl.	= - 13° 34' }

1901.167	89.1	6.37
.203	88.4	6.47
1901.18	88.7	6.42

The only measures since Σ are by Ma and J. No motion.

### Σ 1104. L 14619

R.A.	= 7 <sup>h</sup> 23 <sup>m</sup> 55 <sup>s</sup> }
Decl.	= - 14° 44' }

A and B

1900.780	330.3	2.40
1901.873	333.5	2.30
1901.132	331.9	2.35

A and C. C = 11.7

1900.780	187.6	20.43
1901.203	186.0	20.63
1900.99	186.8	20.53

A and D. D = 11.6

1900.780	5.8	37.88
1901.203	5.7	38.29
1900.99	5.7	38.08

The distant stars not in Σ. A has a proper motion of 0.312 in 216.1. The change in C and D from the measures of Engelmann in 1882 is due to this motion of A.

### H 3973. S.D.(20°)1999. 8.4 ... 9.3

R.A.	= 7 <sup>h</sup> 26 <sup>m</sup> 37 <sup>s</sup> }
Decl.	= - 20° 40' }

1901.873	37.7	9.00
1902.222	38.8	8.65
1902.05	38.2	8.82

H gives 36° 3 : 8' ± (1837.10), and calls the companion "remarkable brick red." It is decidedly reddish. This pair is catalogued as new by See (= λ 81).

### Σ 1115. S.D.(12°)2016. 9.5 ... 9.6

R.A.	= 7 <sup>h</sup> 26 <sup>m</sup> 39 <sup>s</sup> }
Decl.	= - 12° 37' }

1901.873	139.9	12.35
1902.222	140.1	12.12
1902.05	140.0	12.23

Without change. The companion is S.D.(12°) 2017. (See next pair.)

### Δ 13. S.D.(12°)2019. 9.6 ... 13.7 ... 9.7

R.A.	= 7 <sup>h</sup> 27 <sup>m</sup> 20 <sup>s</sup> }
Decl.	= - 12° 34' }

A and B (new)

1901.873	208.8	3.11
1902.222	209.3	2.70
1902.05	209.0	2.90

A and C (= Δ 13)

1901.873	287.6	11.87
1902.222	288.9	11.75
1902.05	288.2	11.81

In the field with Σ 1115; the wide stars noted by Dembowski. The large telescope shows a nearer component. The only measures of AC are :

1867.10	288.4	11.44	2 <sup>u</sup>	J
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### S 555. L 14888. 7.5 ... 7.7

R.A.	= 7 <sup>h</sup> 31 <sup>m</sup> 10 <sup>s</sup> }
Decl.	= - 14° 10' }

1901.206	228.3	95.74
1902.219	228.4	95.77
1901.71	228.3	95.75

Nothing else since South :

1825.00	227.7	94.37	2 <sup>u</sup>	S
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**H 765.** L 14890. 8.6 ... 11 ... 11

R.A. =  $7^h 32^m 30^s$   $\downarrow$   
Decl. =  $+27^\circ 0'$   $\downarrow$

A and B

1901.720	212.8	23.52
.818	212.3	23.59
1901.77	212.5	23.55

A and C

1901.720	296.7	40.84
.818	296.3	40.55
1901.77	296.5	40.69

No other measures. Distances estimated  $15''$  and  $18''$  by H. A has a proper motion of  $0.163$  in  $181.9$ .

**H 2405.** 24 *Lyneis*

R.A. =  $7^h 32^m 51^s$   $\downarrow$   
Decl. =  $+58^\circ 50'$   $\downarrow$

1901.799	319.2	54.50
.854	319.8	54.86
1901.82	319.5	54.68

No other measures. H.  $319.4:60'' \pm$ . The proper motion is small,  $0.077$  in  $217.7$ .

*Procyon*

R.A. =  $7^h 33^m 1^s$   $\downarrow$   
Decl. =  $+5^\circ 33'$   $\downarrow$

A and C

1897.884	341.2	57.40
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**S 560.** 6.5 ... 8.6

R.A. =  $7^h 41^m 0^s$   $\downarrow$   
Decl. =  $+29^\circ 4'$   $\downarrow$

1901.720	358.7	89.50
.818	358.9	89.68
1901.77	358.8	89.59

Without change. The only measures since S are:

1873.24	358.7	89.90	4n	0.2
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**H III. 28.** L 15389. 7.1 ... 10.7

R.A. =  $7^h 46^m 53^s$   $\downarrow$   
Decl. =  $-13^\circ 33'$   $\downarrow$

1901.203	194.1	23.93
.206	195.5	24.07
1901.20	194.8	24.00

H says, "near 9 *Argus*; place very doubtful," and gives the place of 9 *Argus*. His estimate of the distance is  $8''$  (1781). This star has a proper motion of  $0.101$  in  $133.8$ .

**OΣ 183 rej.** 7.5 ... 12

R.A. =  $7^h 47^m 8^s$   $\downarrow$   
Decl. =  $+16^\circ 21'$   $\downarrow$

1901.815	20.4	15.87
.818	20.1	15.71
1901.81	20.2	15.79

Probably unchanged;  $19.8:16.19$  (1878.12)  $3n \beta$

## S.D.(13°)2277. 7 ... 12 ... 12

R.A. =  $7^h 47^m 26^s$   $\downarrow$   
Decl. =  $-13^\circ 45'$   $\downarrow$

A and B

1901.167	161.6	42.39
.203	163.5	41.29
1901.18	162.5	41.84

B and C

1901.203	145.9	4.16
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Measured in looking for H III. 28.

## D.M.(50°)1495. 8.9 ... 8.9

R.A. =  $7^h 49^m 22^s$   $\downarrow$   
Decl. =  $+50^\circ 35'$   $\downarrow$

1901.742	103.6	3.24
.799	104.8	3.17
1901.77	104.2	3.20

"Duplex" in Harvard A.G. The only measures are by Espin,  $285.2:3.14$  (1900.12)  $2n$ .

## D.M.(−1°)1949. 9.5 ... 9.5

R.A. =  $7^h 50^m 47^s$   $\downarrow$   
Decl. =  $-1^\circ 25'$   $\downarrow$

1902.145	178.6	6.62
.222	178.9	6.89
1902.18	178.7	6.75

Described as "duplex or nebulous" in Nico. A.G. No nebulous appearance with the 40-inch.

**W VII. 1609**

R.A.  $\approx 8^{\text{h}} 0^{\text{m}} 7^{\text{s}}$   
Decl.  $\approx 31^{\circ} 54'$

Noted "duplex" in Weiss. It is not double. There are two distant companions, but too remote to be of any interest (1901.72).

**H 3308.** D.M. 35 01767. 7...10.8

R.A.  $\approx 8^{\text{h}} 2^{\text{m}} 21^{\text{s}}$   
Decl.  $\approx 35^{\circ} 49'$

1901.722	263.3	45.81
.742	263.2	45.65
.758	263.4	45.75
1901.74	263.3	45.74

Only H, 234 $^{\circ}$ 6 : 40'  $\pm$  (1831). The principal star has a proper motion of 0.328 in 138 $^{\circ}$ 1. In my first measure A was thought to be a close pair, but not verified.

**H 2430.** D.M. (53) 122. 8.9...12...12.5

R.A.  $\approx 8^{\text{h}} 3^{\text{m}} 49^{\text{s}}$   
Decl.  $\approx 53^{\circ} 43'$

**A and B**

1901.742	311.2	20.44
.799	309.4	20.37
1901.77	310.3	20.40

**B and C**

1901.742	184.0	8.20
.799	180.2	8.55
1901.77	182.1	8.37

H gives 311 $^{\circ}$ 5 : 15'  $\pm$  and 177 $^{\circ}$   $\pm$  : 3'  $\pm$  and mags. 8, 13, and 14. No other measures. The magnitude in D.M. is 9.2.

**OS 190 rej.**

R.A.  $\approx 8^{\text{h}} 12^{\text{m}} 36^{\text{s}}$   
Decl.  $\approx 47^{\circ} 48'$

**A and  $\alpha$  Hussey 224**

1901.742	316.3	4.09
.854	317.3	4.09
1901.80	316.8	4.09

**A and B**

1901.742	167.4	38.57
.854	167.6	38.43
1901.80	167.5	38.50

**A and C**

1901.742	280.4	77.60
.854	280.5	77.70
1901.80	280.4	77.65

**H V. 109.** 6...10.5

R.A.  $\approx 8^{\text{h}} 19^{\text{m}} 27^{\text{s}}$   
Decl.  $\approx 7^{\circ} 57'$

1901.203	342.6	31.22
1902.142	342.1	31.70
.145	342.9	31.32
1901.83	342.5	31.41

The only earlier measures are:

1783.14	325.0	35.40	1 $\alpha$	H
1880.61	343.0	31.86	2 $\alpha$	$\beta$

The large star does not appear to have any sensible proper motion. Probably without change.

**A.G.C. 3.**  $\rho$  *Hydrae*. 5...12.5

R.A.  $\approx 8^{\text{h}} 42^{\text{m}} 5^{\text{s}}$   
Decl.  $\approx 6^{\circ} 17'$

1901.873	146.5	12.05
1902.145	145.5	12.04
1902.01	146.0	12.04

Discovered by Alvan G. Clark with the McCormick 26-inch. Apparently without change.

1878.07	144.9	12.40	3 $\alpha$	$\beta$
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**H 4146.** L 17541. 6.7...12

R.A.  $\approx 8^{\text{h}} 46^{\text{m}} 48^{\text{s}}$   
Decl.  $\approx -12^{\circ} 47'$

1901.167	103.2	34.00
.203	102.9	33.68
1901.18	103.0	33.84

H gives 99 $^{\circ}$ 2 : 35'  $\pm$  : 6...14 (1836). His R.A. is 1 $^{\text{m}}$  in error.

**S 585.** 6...6.3

R.A.  $\approx 8^{\text{h}} 49^{\text{m}} 4^{\text{s}}$   
Decl.  $\approx 17^{\circ} 45'$

1901.167	146.9	66.82
.203	146.9	66.81
1901.18	146.9	66.83

S gives 323 $^{\circ}$ 2 : 69.36 (1825.22) 3 $\alpha$ . These stars are L 17636 and 17638.

**Schjellerup 11.** 9.1 . . . 9.2

R.A.  $- 9^h 1^m 36^s$   $\downarrow$   
Decl.  $- + 0^{\circ} 16'$   $\downarrow$

1901.203	259.2	6.46
1902.222	261.3	6.53
1901.72	260.2	6.50

First noted by Schjellerup, and given with estimated position. The principal star is D.M.(0°)2462. There is no evidence of motion. The only other measures are:

1874.26    260.9    6.21    2*n*    J

**H VI. 47.** 3 *Leonis*. 6 . . . 10.5

R.A.  $- 9^h 22^m 4^s$   $\downarrow$   
Decl.  $- + 8^{\circ} 43'$   $\downarrow$

1901.167	80.2	24.90
.299	79.3	24.84
1901.23	79.7	24.87

No measures by H. The later positions do not show any material change. The only other measures are:

1852.19    81.6    25.71    2*n*    Lassell  
1879.48    79.2    25.14    3*n*     $\beta$

 **$\tau$  Hydræ.** H VI. 71 = Sh 106 = H 1167

R.A.  $- 9^h 23^m 3^s$   $\downarrow$   
Decl.  $- - 2^{\circ} 15'$   $\downarrow$

1901.206	3.7	65.29
.299	3.3	65.31
1901.25	3.5	65.30

The A.G. proper motion of A is 0.118 in 91.9, and B (L 18661) 0.180 in 90. As they are moving at nearly the same rate, there is little change.

This pair was subsequently observed and catalogued by Sir John Herschel as H 1167, but given with an error of 1° in the declination. There is no doubt of its identity with  $\tau$  *Hydræ*.

1800	1.4	66.12		Lalande
1821.23	3.2	66.68	1 <i>n</i>	Sh
1887.3	3.0	65.32		A.G.

**S 604.** L 18884. 7.1 . . . 8.7

R.A.  $- 9^h 29^m 59^s$   $\downarrow$   
Decl.  $- - 19^{\circ} 2'$   $\downarrow$

1901.206	90.5	51.44
1902.222	90.5	51.20
1901.71	90.5	51.32

The only other measures are:

1825.17    90.5    51.84    2*n*    S

**S 611.** S.D.(13')3193-4. 9 . . . 9

R.A.  $- 10^h 35^m 53^s$   $\downarrow$   
Decl.  $- - 14^{\circ} 5'$   $\downarrow$

1902.145	193.9	59.60
.219	193.3	59.55
1902.18	193.6	59.57

The only other measure is:

1825    193.8    59.33    1*n*    S

**H 838.** 41 *Sextantis*. 6 . . . 11.7

R.A.  $- 10^h 44^m 17^s$   $\downarrow$   
Decl.  $- - 8^{\circ} 16'$   $\downarrow$

1901.299	303.9	27.04
.337	302.2	27.06
1901.32	303.0	27.05

The only other measures are 303.8; 26.95 (1878.18) 1*n*  $\beta$ . H called the small star 17-18*m*.

**S 617.** 6.6 . . . 8.5

R.A.  $- 10^h 47^m 19^s$   $\downarrow$   
Decl.  $- - 1^{\circ} 37'$   $\downarrow$

1901.167	177.8	35.25
.203	178.3	35.42
1901.18	178.0	35.33

The proper motion in the A.G. is 0.130 in 230.1 for each star. The components are L 20956 and 20957.

1800	179.7	34.11		Lalande
1824.22	177.8	35.22	2 <i>n</i>	S
1880.66	178.6	35.09	3 <i>n</i>	Schiap

**H 4410.** O.Arg.S.11162. 7.5 . . . 13

R.A.  $- 11^h 2^m 19^s$   $\downarrow$   
Decl.  $- - 15^{\circ} 19'$   $\downarrow$

1901.206	222.6	19.33
.299	221.8	19.71
1901.25	222.2	19.82

Only H, 205.3; 15' (1836.4). He calls it "difficult," so the apparent change in angle may not be real.

**H 177.** S.D.(2) 3297. 9.6 . . . 10.1

R.A.  $- 11^h 3^m 21^s$   $\downarrow$   
Decl.  $- - 2^{\circ} 46'$   $\downarrow$

1901.206	128.1	4.93
.299	131.1	4.87
1901.25	129.6	4.90

H gives  $110^{\circ} \pm 2'$ , and says, "hardly divided with the sweeping power."

**Σ 1518** *rej.* D.M.(6°)2421. 7.5 . . . 9.7 . . . 9.9

R.A. =  $11^h 58^m 18^s$  }  
 Decl. =  $- 5^{\circ} 55'$  }

B and C Σ 1518 *rej.*

1901.167	350.5	2.80
.299	353.0	3.69
.318	353.2	3.72

1901.26	352.2	3.40
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A and B

1901.167	256.7	103.49
.299	256.2	103.52

1901.23	256.4	103.50
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No other measures. Described as Class I in Σ.

**W<sup>+</sup> XI. 621.**

R.A. =  $11^h 33^m 17^s$  }  
 Decl. =  $+ 21^{\circ} 59'$  }

This star (= D.M.(22°)2387) is noted "duplex 3'" in Weisse. Examined on two nights in 1901, but not seen double or with any near companion. It is a curious fact that in the Berlin A.G. this star has the note, "Comp. 9.5 1'-2'?" It is about 1<sup>m</sup> *p* 93 *Leonis*. I examined the star in question in May, 1874, with the 6-in. without seeing it double.

**H 2955**

R.A. =  $11^h 59^m 16^s$  }  
 Decl. =  $+ 39^{\circ} 20'$  }

The description in H is  $315^{\circ} \pm : 15' \pm : 8 \dots 18$  (1830); "extremely faint." Examined on two nights, and no companion visible.

**Σ 1601**

R.A. =  $12^h 0^m 23^s$  }  
 Decl. =  $+ 39^{\circ} 30'$  }

1901.203	311.6	2.45
.318	311.7	2.31

1901.26	311.6	2.38
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Measured in looking for the preceding pair, H 2955.

**H 203. W<sup>+</sup> XII. 94. 6.8 . . . 12.7**

R.A. =  $12^h 8^m 6^s$  }  
 Decl. =  $- 5^{\circ} 3'$  }

1901.203	351.9	26.62
.206	351.3	25.77
.318	350.7	26.18

1901.24	351.3	26.19
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The only other measures are:

1878.24 351.6 30.20 *In β*

The principal star has a proper motion of 0.184 in 319.5, which evidently does not belong to the small star.

**Ho 52. 11 Comae. 5 . . . 12.3**

R.A. =  $12^h 14^m 39^s$  }  
 Decl. =  $+ 18^{\circ} 27'$  }

1901.203	45.4	9.15
.299	41.6	9.16
.356	43.7	9.13

1901.28	43.6	9.15
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The large star has a proper motion of 0.145 in 308.3. Comparing these positions with those of Hough in 1892, it is very probable that the small star has the same movement.

**Albany A.G. D.M.(2°)2550. 8.5 . . . 8.8**

R.A. =  $12^h 25^m 5^s$  }  
 Decl. =  $+ 2^{\circ} 46'$  }

1901.356	286.9	1.40
.375	287.5	1.24

1901.36	287.2	1.32
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Noted "duplex?" in the Albany Catalogue. This is a new pair; no other measures.

**Pritchett.**

R.A. =  $12^h 31^m 0^s$  }  
 Decl. =  $- 7^{\circ} 0'$  }

A double star is given in this place in the Morrison Observations, 76°8 : 5'89 (1880.36) *In*; magnitudes not given. I carefully examined the place and vicinity without finding any pair of this description. It should be a short distance *p* the 5m star, 26 *Virginis*.

**H 522. 30 Comae. 6 . . . 11.7**

R.A. =  $12^h 45^m 51^s$  }  
 Decl. =  $+ 28^{\circ} 13'$  }

1901.318	11.8	42.46
.337	11.3	43.22
.356	12.0	43.08

1901.34	11.7	42.92
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The only other measures are 10°0 : 43'17 (1878.15) *In β*. H gave the magnitudes 6 and 18. His R.A. is about 2½<sup>m</sup> too small. The proper motion is 0.115 in 287.7.

**$\delta$  Virginis.**  $3\frac{1}{2} \dots 10.5$ 

R.A. =  $12^h 49^m 34^s$  }  
 Decl. =  $+4^\circ 3'$  }

1901.203	139.2	157.81
.263	140.2	158.26
.414	139.4	158.13
1901.29	139.6	158.07

The principal star has a proper motion of  $0.499$  in  $263^\circ 1$ . The only other measures are:

1879.30	142.3	152.03	$2n$	$\beta$
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The computed place of the companion for 1901, from the first measures and the proper motion, is  $139^\circ 9' : 158^\circ 00'$ .

**H 2645.**  $53$  Virginis.  $B = 11.8$ 

R.A. =  $13^h 5^m 40^s$  }  
 Decl. =  $-15^\circ 33'$  }

1901.299	7.3	77.59
.318	6.9	76.52
.356	7.8	77.16
1901.32	7.3	77.09

No other measures. H estimates  $30^\circ \pm : 50^\circ \pm$  (1830). The large star has a proper motion of  $0.289$  in  $164^\circ 8$ .

**O $\Sigma$  261**

R.A. =  $13^h 6^m 24^s$  }  
 Decl. =  $+32^\circ 31'$  }

1889.288	344.9	1.45
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**Sh 162.**  $7.2 \dots 7.7$ 

R.A. =  $13^h 8^m 39^s$  }  
 Decl. =  $-10^\circ 43'$  }

1902.145	50.8	71.14
.219	50.5	71.30
1902.18	50.6	71.22

The principal star has a proper motion of  $0.388$  in  $219^\circ 4$ . The components are respectively L 24582 and 24584.

1823.34	61.7	44.85	$1n$	Sh
1881.37	52.5	64.60	$3n$	$\beta$

**H IV. 119.** S.D.(12°)3802.  $7.5 \dots 10$ 

R.A. =  $13^h 16^m 25^s$  }  
 Decl. =  $-12^\circ 33'$  }

1902.145	312.2	19.29
.219	310.5	19.04
1902.18	311.3	19.16

The companion is S.D.(12°)3801. This pair has been entirely neglected by observers since H, and the only measures are:

1783.18	306.9	21.82	$1n$	H
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 **$\Sigma$  1739 rej.** D.M.(31°)2478.  $9.2 \dots 10$ 

R.A. =  $13^h 16^m 57^s$  }  
 Decl. =  $+31^\circ 9'$  }

1902.145	132.7	12.93
.219	131.7	12.63
1902.18	132.2	12.78

No other measures.

**75 Virginis.**  $5 \dots 13.5 \dots 12$ 

R.A. =  $13^h 26^m 27^s$  }  
 Decl. =  $-14^\circ 45'$  }

A and B

1902.145	321.0	18.82
.219	319.3	18.98
1902.18	320.1	18.90

A and C (= H 2658)

1902.145	109.9	79.74
.219	110.1	79.50
1902.18	110.0	79.62

The faint star not previously seen. The only complete measures of AC are:

1879.31	110.1	78.29	$2n$	$\beta$
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 **$\Sigma$  1757**

R.A. =  $13^h 28^m 9^s$  }  
 Decl. =  $+0^\circ 18'$  }

1901.203	76.7	2.41
.263	78.8	2.59
.280	78.9	2.35
1901.25	78.1	2.45

Although two orbits have been computed of this pair, the motion seems to be purely rectilinear, the change being due to the difference of the two proper motions. That of the principal star is  $0.270$  in  $277^\circ 9$ . (See *Popular Astronomy*, IV, 172.)

**H 2659**

R.A. =  $13^h 28^m 11^s$  }  
 Decl. =  $+40^\circ 33'$  }

The description in H is  $315^\circ \pm : 10^\circ : 8.9 \dots 18$ ; "requires verifying." I could not see this companion

with the 18 $\frac{1}{2}$ -in. in 1878, nor with the 40-in., 1901.20. The nearest star is 13m. 202°3 : 38'7. It is probable that H was mistaken. His place is that of D.M.(40°) 2666, given as 7.4m.

 **$\beta$  611**

R.A. = 13<sup>h</sup> 31<sup>m</sup> 15<sup>s</sup> }  
Decl. = - 14° 7' }

1901.299	260.5	4.56
.356	260.1	4.79
1901.33	260.3	4.67

Measured in looking for the Egbert pair.

**H 2666. S.D.(14°)3763**

R.A. = 13<sup>h</sup> 32<sup>m</sup> 2<sup>s</sup> }  
Decl. = - 14° 13' }

1901.299	177.6	13.83
.318	179.4	14.87
.356	182.4	14.19
1901.32	179.8	14.30

H gives 176°7 : 8'  $\pm$  : 9 ... 15 (1830).

**Egbert**

R.A. = 13<sup>h</sup> 34<sup>m</sup> : }  
Decl. = - 14° 26' }

Measured once at Cincinnati, 349°3 : 11'70 : 9 ... 10 (1879.30). There is no such pair in or near this place. About 2<sup>m</sup>f there is a small pair, 0°5 : 15'43 : 8.5 ... 13.5 (1901.35) 1n. This star is S.D.(14°)3783. The descriptions do not correspond.  $\beta$  611 is in the same vicinity.

 **$\Sigma$  1774 rej. 7 ... 10.5**

R.A. = 13<sup>h</sup> 35<sup>m</sup> 39<sup>s</sup> }  
Decl. = + 51° 7' }

1901.337	133.7	17.87
.356	134.1	17.83
1901.34	133.9	17.85

The principal star is given in Harvard A.G. a proper motion of 0.172 in 305°1. The only prior measures are:

1879.26	134°2	17.93	1n	$\beta$
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The distance now should be 3.7 more, if the proper motion is correct and the small star is fixed.

**H 2676. D.M.(50°)2021. 7.8 ... 9.7**

R.A. = 13<sup>h</sup> 38<sup>m</sup> 12<sup>s</sup> }  
Decl. = + 50° 38' }

1901.337	126.0	29.67
.356	125.0	29.66
1901.34	125.5	29.66

Recently measured by Espin. Nothing else since H.

 **$\Sigma$  1782.**

R.A. = 13<sup>h</sup> 39<sup>m</sup> 22<sup>s</sup> }  
Decl. = + 18° 58' }

1902.145	185.6	29.72
.219	185.0	29.67
1902.18	185.3	29.69

No recent measures, but unchanged.

**Howe. D.M.(6°)2824. 9 ... 9.1 ... 11**

R.A. = 13<sup>h</sup> 57<sup>m</sup> 22<sup>s</sup> }  
Decl. = + 6° 22' }

A and B

1901.203	65.6	0.93
.263	64.9	0.92
1901.23	65.2	0.92

AB and C

1901.203	189.3	14.33
.263	188.7	14.20
1901.23	189.0	14.26

No recent measures. Probably unchanged. Identified as above.

 **$\Sigma$  1801**

R.A. = 13<sup>h</sup> 59<sup>m</sup> 27<sup>s</sup> }  
Decl. = + 6° 32' }

1901.203	67.5	19.51
.263	68.4	19.72
1901.23	67.9	19.61

**Howe. S.D.(12°)3958. 8.2 ... 8.7**

R.A. = 13<sup>h</sup> 59<sup>m</sup> 30<sup>s</sup> }  
Decl. = - 12° 30' }

1901.203	7.5	13.46
.225	7.6	13.34
.299	7.6	13.34
1901.24	7.6	13.38

The original place is only approximate. The R.A. is about  $2^m$  in error. The only other measures are in 1879. Apparently fixed.

### 13 Bootis. H VI. 112. 5...9.5

R.A. =  $14^h 3^m 48^s$  }  
Decl. =  $+50^\circ 1'$  }

1902.219	274.3	81.14
.222	274.4	80.99
1902.22	274.3	81.06

The companion is preceding the other. The only measures are:

1783.63	82.6	77.97	1n	H
1879.33	95.0	83.47	1n	Cin

The proper motion of the principal star is very small,  $0.06$  in  $323^\circ$ .

### $\Sigma$ 1807

R.A. =  $14^h 5^m 6^s$  }  
Decl. =  $-2^\circ 46'$  }

1901.203	28.8	6.88
.299	26.0	6.88
1901.25	27.4	6.88

### H 1248. 12...12.2

R.A. =  $14^h 9^m 58^s$  }  
Decl. =  $+7^\circ 54'$  }

1901.356	163.2	7.90
.370	163.9	7.99
1901.36	163.5	7.94

H gives  $340^\circ \pm 2^\circ \pm 16 \dots 16.17$  (1828), and says, "The most minute double star I have hitherto seen." It is a little  $s$  of the  $9.4m$  star, D.M.( $8^\circ$ )2834. As in nearly all cases of this kind, H greatly underestimated the distance.

### Howe. D.M.( $24^\circ$ )2711. 8.5...10.0

R.A. =  $14^h 11^m 6^s$  }  
Decl. =  $+24^\circ 2'$  }

1902.145	79.2	3.35
.219	78.6	3.48
1902.18	78.9	3.41

Howe (Cin.<sup>5</sup>) measured a pair in this place, 1937:  $5.42 : 8.5 \dots 10.5$  (1879.35) 1n. Unless there is a large error in the measure or the place, there would seem to be considerable relative motion. There is no other pair in the vicinity.

### Espin. D.M.( $52^\circ$ )1792. 9...10.3...9

R.A. =  $14^h 16^m 15^s$  }  
Decl. =  $+52^\circ 13'$  }

A and B

1902.145	46.8	1.75
.219	47.8	1.68
1902.18	47.3	1.71

A and C

1902.145	170.6	40.83
.219	170.1	40.86
1902.18	170.3	40.84

Discovered by Espin. No other measures of AB. The A.G. positions give for AC  $190^\circ 1 : 41.75$  (1875.7).

### H 2714. (= Ho 385). 7...11

R.A. =  $14^h 17^m 18^s$  }  
Decl. =  $-19^\circ 15'$  }

1901.263	280.1	23.09
.280	278.4	23.05
1901.27	279.2	23.07

The angle seems to be increasing;  $266^\circ 4$  (1830)H;  $276^\circ 1$  (1879) $\beta$ ;  $277^\circ 0$  (1891)Ho. The principal star is L 26283.

### H 546. S.D.( $12^\circ$ )4042. 7...10.4

R.A. =  $14^h 18^m 48^s$  }  
Decl. =  $-12^\circ 49'$  }

1902.145	42.6	39.35
.219	42.2	39.43
1902.18	42.4	39.39

The R.A. in H is  $4^m$  too small, and the Decl. about  $1^\circ$  too small. He called the components red and blue. No other measures.

### $\Sigma$ 1852 rej. B.A.C. 4799. 7.2...9.5

R.A. =  $14^h 23^m 45^s$  }  
Decl. =  $-3^\circ 43'$  }

1901.225	267.9	24.74
.263	268.1	24.63
1901.24	268.0	24.68

No early measures.  $\beta$   $268^\circ 1 : 25.16$  (1879.30) 3n.

**H 2728.  $\rho$  Bootis.** 4...12.5

R.A. =  $14^h 26^m 42^s$  /  
Decl. =  $-30^\circ 54'$  }

1902.145      335.9      50.14

.219      335.8      49.98

1902.18      335.8      50.06

Meridian positions give for the proper motion  
0.151 in 316.9. The earliest complete measures are:

1879.87      334.0      53.25       $2n$        $\beta$

**Hd Zones. D.M.(1°)2964**

R.A. =  $14^h 25^m 38^s$  /  
Decl. =  $+0^\circ 54'$  }

In Harvard Zones "appeared elongated." I could  
see no sign of duplicity (1901.20). If double, it must  
be very close.

**Sh 186.  $\alpha$  Librae**

R.A. =  $14^h 41^m 12^s$  /  
Decl. =  $-15^\circ 32'$  }

1901.280      314.0      231.08

.299      314.2      230.97

1901.29      314.1      231.02

No recent measures. The smaller star is *8 Librae*.  
Auwers gives 0.168 in 237.6 for the p.m. of A, and  
0.153 in 241.9 for the other.

1755	314.9	231.18	Bradley
1823	314.5	230.85	Sh
1880	314.4	230.70	Gr. 10-year

**H 564. D.M.(29°)2618. 8...11.4**

R.A. =  $14^h 59^m 11^s$  /  
Decl. =  $+29^\circ 33'$  }

1901.206      32.9      41.18

.225      32.6      41.34

1901.21      32.7      41.26

H gives 20...15...16...20 (1820). There is  
no bright star in his place. The one measured has  
the same R.A., but is about 20", and is probably  
the star in question.

 **$\Sigma$  1936. D.M.(27°)2478**

R.A. =  $15^h 16^m 2^s$  /  
Decl. =  $-27^\circ 28'$  }

1901.206      231.5      20.36

.318      232.0      20.30

1901.26      231.7      20.33

No recent measures, and only Ma and J since  $\Sigma$ .  
Put on the list to identify and get correct place.  
Error in *Mens. Microm.* Without change.

**O $\Sigma$  (App.) 140. 8...8**

R.A. =  $15^h 26^m 38^s$  /  
Decl. =  $+8^\circ 59'$  }

1901.471      179.7      111.96

.512      179.8      112.32

1901.49      179.7      112.14

The only other measures are by J, 179.9: 111.85  
(1874.97)  $2n$ . The components are L 28309 and  
28310.

 **$\gamma$  Librae. 4.5...11.7**

R.A. =  $15^h 28^m 48^s$  /  
Decl. =  $-14^\circ 23'$  }

1901.471      152.5      42.04

1902.219      152.9      41.81

1901.84      152.7      41.92

Companion first noted by Goldschmidt (*Comp.*  
*Rend.* LVI, 845). The only previous measure is:

1878.32      151.8      41.51       $1n$        $\beta$

**O $\Sigma$  297. 8...11.5**

R.A. =  $15^h 29^m 40^s$  /  
Decl. =  $+25^\circ 25'$  }

1901.318      138.6      4.24

.320      136.2      4.81

.395      137.1      4.77

1901.34      137.3      4.61

The change is due to proper motion. I do not  
find this is given from meridian positions. From all  
the measures Hussey gets 0.149 in 156.5 for the  
movement of A.

**W<sup>2</sup> XV. 752 = D.M.(23°)2838**

R.A. =  $15^h 33^m 10^s$  /  
Decl. =  $+23^\circ 41'$  }

Noted in Weisse "duplex?" A 7.4m star, and  
certainly not double (1901.28).

**D.M.(4°)3055. 8.5...9.0**

R.A. =  $15^h 39^m 22^s$  /  
Decl. =  $+4^\circ 55'$  }

1901.375      146.3      2.19

.395      144.9      2.09

1901.38      145.6      2.14

Noted as double,  $160'' : 2'$ , in the Albany A.G. Not in any double-star catalogue, and no other measures.

**Pritchett.** D.M.(36°)2640. 9...9

R.A. =  $15^h 40^m 12^s$  }  
Decl. =  $+ 35^\circ 59'$  }

1901.359	44.4	4.46
.395	46.0	4.58
1901.38	45.2	4.52

Discovered by Pritchett, who found  $45^\circ 1 : 3' 94$  (1881.52) 1n. No other measures.

**Skinner.** S.D.(16°)4169. 8.5...8.7

R.A. =  $15^h 45^m 32^s$  }  
Decl. =  $16^\circ 52'$  }

1901.455	275.2	2.02
.471	273.0	2.00
1901.46	274.1	2.01

Noted as double by Professor Skinner at the Naval Observatory. No other measures.

**H 1281.** L 28977. 7.1...11

R.A. =  $15^h 50^m 17^s$  }  
Decl. =  $- 15^\circ 41'$  }

1901.280	230.9	34.43
.299	231.3	34.38
1901.29	231.1	34.40

H estimated  $215^\circ : 18' : 6-7...20$ . The only other measures are  $229^\circ 8 : 35' 12$  (1890.36) 1n  $\beta$ .

**W XVI. 2.** 8.4...9.2

R.A. =  $16^h 2^m 27^s$  }  
Decl. =  $+ 20^\circ 42'$  }

1901.356	224.6	12.12
.375	224.9	12.22
1901.36	224.7	12.17

In Weisse "duplex  $12''$ ." No other measures.

**$\Sigma$  2017**

R.A. =  $16^h 6^m 37^s$  }  
Decl. =  $+ 14^\circ 52'$  }

1900.455	252.9	26.64
.458	252.8	26.55
1900.45	252.8	26.60

Perhaps a small change in distance.  $\Sigma$  found  $25^\circ 03$  (1881.42), and  $\Delta$   $25^\circ 95$  (1867.65).

**$\Sigma$  2018 rej.** S.D.(7°)4234. 8.1...9.1

R.A. =  $16^h 7^m 10^s$  }  
Decl. =  $- 7^\circ 20'$  }

1901.359	355.3	19.51
.375	355.8	19.36
.455	355.0	19.60
1901.39	355.4	19.51

No other measures. Identified as above.

**$\Sigma$  2019 rej.** S.D.(10°)4276. 8...9.2

R.A. =  $16^h 7^m 42^s$  }  
Decl. =  $10^\circ 7'$  }

1900.455	152.7	22.48
.458	153.0	22.25
1900.45	152.8	22.36

The only other measures are in the Washington Observations of 1862,  $109^\circ 2 : 19' 11$  (1862.7). This may be another star.

**$\Sigma$  2031 rej.** D.M.( $-1^\circ$ )3761. 7.6...9.7

R.A. =  $16^h 10^m 9^s$  }  
Decl. =  $- 1^\circ 21'$  }

1901.359	230.2	20.80
.395	229.5	20.85
.416	230.0	20.66
1901.39	229.9	20.77

No other measures; Class IV in  $\Sigma$ . The principal star is L 29649, and has a proper motion of  $0.105$  in  $270^\circ$ .

**$\sigma$  Coronae**

R.A. =  $16^h 10^m 12^s$  }  
Decl. =  $+ 34^\circ 10'$  }

A and B (=  $\Sigma$  2032)

1901.263	213.6	4.34
.320	212.8	4.30
1901.29	213.2	4.32

B and C (=  $\sigma$   $\Sigma$  538)

1901.263	202.7	5.58
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The distance of the 13.5m star is diminishing from the proper motion of AB.

**$\Sigma$  3103 rej.** S.D.(3°)3921. 8.8...9.7

R.A. =  $16^h 14^m 24^s$  }  
Decl. =  $- 3^\circ 40'$  }

1901.395	305.3	24.18
.414	304.9	24.56
1901.40	305.1	24.37

No other measures.

**$\beta$  624**

R.A. =  $16^{\text{h}} 15^{\text{m}} 42^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-22^{\circ} 50' \frac{1}{2}$

1901.359	320.4	1.19
.433	323.5	1.21
1901.40	321.9	1.20

Observed in trying to find H 4851.

**Anon. S.D.(3'')3929, 3930. 7.6...8.7**

R.A. =  $16^{\text{h}} 16^{\text{m}} 11^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-3^{\circ} 58' \frac{1}{2}$

1901.375	22.4	99.70
.416	22.5	99.97
1901.39	22.4	99.83

Measured in connection with  $\Sigma$  3103 *rej.* The meridian positions in Lamont give  $22^{\text{h}} 7^{\text{m}} : 92^{\text{m}} 44^{\text{s}}$  (1855.5).

**H 4851**

R.A. =  $16^{\text{h}} 17^{\text{m}} 7^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-22^{\circ} 45' \frac{1}{2}$

The description in H is  $96^{\circ} 9' 15'' \pm : 8 \dots 11$  (1837.2). I looked in vain for this object in 1891, and again in 1901. There is no such star in or near this place. I see now that there is an error of  $1^{\text{h}}$  R.A. in this place, and that the star is identical with H 4948, which is  $17^{\text{h}} 17^{\text{m}} 10^{\text{s}} : 22^{\circ} 42'$ . The descriptions correspond perfectly. Measures of that will be found here in the proper place.

 **$\Sigma$  2038 *rej.* D.M.(2'')3091. 8.6...10.4**

R.A. =  $16^{\text{h}} 17^{\text{m}} 29^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-2^{\circ} 30' \frac{1}{2}$

1901.455	214.7	16.49
.471	213.7	16.41
1901.46	214.2	16.45

No other measures.

 **$\Sigma$  2042 *rej.* D.M.(6'')3225. 8.3...11.1**

R.A. =  $16^{\text{h}} 19^{\text{m}} 56^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-5^{\circ} 50' \frac{1}{2}$

1901.375	108.9	20.28
.395	108.3	20.58
.414	109.4	20.20
1901.39	108.9	20.35

No other measures.

 **$\beta$  815. D.M.(43'')2605. 8.3...10.5**

R.A. =  $16^{\text{h}} 23^{\text{m}} 16^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $+43^{\circ} 11' \frac{1}{2}$

A and B

1901.375	340.8	9.19
.395	340.9	9.09
.397	340.2	9.22
.414	340.2	9.13
.416	340.7	9.28
1901.40	340.56	9.18

A and C (C = 11.5)

1901.375	160.4	67.71
.395	160.4	67.79
.397	160.6	67.95
.414	161.5	67.55
.416	160.6	67.80
1901.40	160.7	67.76

B and C

1901.375	160.3	76.95
.395	160.3	77.40
.397	160.7	77.15
.414	160.9	77.09
.416	160.5	77.23
1901.40	160.5	77.16

It will be remembered that B has a large proper motion for so small a star. I have measured the faint star C, which is exactly in line with AB, for the purpose of determining whether any of the change in AB is due to the movement of A. I have also compared the latter star with D.M.43 2608, and find for the difference of Declination  $22^{\text{m}} 52^{\text{s}}$  (1901.41). This difference in the A.G. is  $22^{\text{m}} 2^{\text{s}}$ , so that it is practically certain that A has no appreciable proper motion. My measures of AB in 1881, and those given here, give for the proper motion of B,  $0^{\text{m}} 147^{\text{s}}$  in  $323^{\text{m}} 3^{\text{s}}$ .

**Sh 233**

R.A. =  $16^{\text{h}} 25^{\text{m}} 43^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $+8^{\circ} 33' \frac{1}{2}$

1900.551	71.3	58.90
1901.210	71.1	58.80
1900.88	71.2	58.85

Relatively fixed.  $71^{\text{m}} 8^{\text{s}} : 58^{\text{m}} 86^{\text{s}}$  (1858.48)  $2n \ 02$ . In 1874 I thought that one of these stars was a close double, but both were round in the last measure with fine seeing.

**Hd Zones.** L 30078. 9...9.1

R.A. =  $16^{\text{h}} 26^{\text{m}} 10^{\text{s}}$  }  
 Decl. =  $+ 0^{\circ} 28'$  }

1901.375	305.7	6.94
.414	303.3	6.94
.455	305.7	6.92
1901.41	304.9	6.93

Noted as double in the Harvard Zones, and also in the Göttingen Catalogue. No other measures. In the field about 3's is a 10m star with a double companion.

**H 4864.** S.D.(6°)4457. 9.5...12.8

R.A. =  $16^{\text{h}} 26^{\text{m}} 49^{\text{s}}$  }  
 Decl. =  $- 6^{\circ} 19'$  }

## A and B

1900.455	91.4	10.07
.458	89.8	10.25
1901.433	87.7	10.39
1900.78	89.6	10.24

## A and C (C = 14.5)

1900.455	134.8	13.55
.458	140.4	13.22
1900.45	137.6	13.38

Simply described in H as "triple Classes I and II." There is a 10m star,  $234^{\circ}3 : 73^{\circ}2$ .

**Σ 2062.** 8.4...10.5

R.A. =  $16^{\text{h}} 28^{\text{m}} 42^{\text{s}}$  }  
 Decl. =  $+ 8^{\circ} 56'$  }

1900.458	111.5	2.55
.551	113.6	2.50
1900.50	112.5	2.52

The only measures since 1857 are my own in 1880. There is no change.

**Young.** D.M.(58°)1646. 8.2...9.5

R.A. =  $16^{\text{h}} 29^{\text{m}} 26^{\text{s}}$  }  
 Decl. =  $+ 58^{\circ} 1'$  }

1901.375	216.5	1.30
.433	214.9	1.48
1901.40	215.7	1.38

Discovered by Professor Young,  $219^{\circ}5 : 1^{\circ}59$  (1883.76) 1n.

**Σ 2069 rej.** L 30278. 6.8...10.4

R.A. =  $16^{\text{h}} 31^{\text{m}} 55^{\text{s}}$  }  
 Decl. =  $+ 34^{\circ} 4'$  }

1901.356	72.6	26.82
.375	71.8	26.56
.395	71.1	26.62
1901.37	71.8	26.67

No other measures.

**Σ 2081 rej.** L 30416. 7.8...10.5

R.A. =  $16^{\text{h}} 37^{\text{m}} 4^{\text{s}}$  }  
 Decl. =  $+ 3^{\circ} 41'$  }

1901.375	321.9	21.31
.414	322.2	21.40
1901.39	322.0	21.35

A more distant companion of about same magnitude,  $178^{\circ}2 : 42^{\circ}3$ . No other measures.

**Σ 2093 rej.**  $\eta$  *Herculis*. 3...12

R.A. =  $16^{\text{h}} 38^{\text{m}} 47^{\text{s}}$  }  
 Decl. =  $+ 39^{\circ} 9'$  }

1901.337	262.2	114.27
.356	262.2	114.27
1901.34	262.2	114.27

Principal star round. The only measures of the small star are  $261^{\circ}1 : 113^{\circ}39$  (1879.27) 1n  $\beta$ .

**Skinner.** S.D.(17°)4630. 8.4...8.5

R.A. =  $16^{\text{h}} 39^{\text{m}} 20^{\text{s}}$  }  
 Decl. =  $- 17^{\circ} 8'$  }

1901.455	86.7	3.46
.473	85.5	3.69
1901.46	86.1	3.57

Discovered by Professor Skinner at the Naval Observatory with the meridian instrument. No other measures.

**H 1294.** L 30509. 7...12.5

R.A. =  $16^{\text{h}} 40^{\text{m}} 56^{\text{s}}$  }  
 Decl. =  $- 24^{\circ} 19'$  }

1900.455	131.3	24.95
1901.433	132.3	25.03
1900.94	131.8	24.99

No other measures. H gives  $135^{\circ}\pm : 18^{\circ}\pm : 7$  ... 17; "large star red." To me it appeared yellow only.

**$\Sigma$  3108 *rej.* L 30945. 8.4 ... 9.0**

R.A. =  $16^{\text{h}} 55^{\text{m}} 43^{\text{s}}$  /  
Decl. =  $-11^{\circ} 43'$  /

1901.455	124.8	39.60
1902.219	124.7	39.73
1901.83	124.7	39.66

No other measures.

**Howe. S.D.(10<sup>5</sup>) 4619. 8.7 ... 12.7**

R.A. =  $16^{\text{h}} 56^{\text{m}} 41^{\text{s}}$  /  
Decl. =  $-20^{\circ} 13'$  /

1900.455	180.9	6.15
1902.430	171.0	6.21
1901.44	177.4	6.18

The only prior measure is a single observation of the position-angle  $182^{\circ} 6'$  (1879.55), with only approximate place. H 4911, which is about  $2\frac{1}{2}^{\text{m}}$  *p* of this, was suspected by H to have a small companion. I have looked for it several times. It is certainly single. His place is that of O.Arg.S. 16213.

**H 2804. 9.5 ... 9.6**

R.A. =  $17^{\text{h}} 0^{\text{m}} 31^{\text{s}}$  /  
Decl. =  $+39^{\circ} 9'$  /

1902.219	277.7	15.14
.433	277.8	15.19
1902.32	277.7	15.16

Not in D.M. Previous measures discordant.

1830+	283.8	$20^{\circ} \pm$	1 <i>n</i>	H
1880.48	280.4	17.25	2 <i>n</i>	Bigourdan
1900.53	278.3	15.44	2 <i>n</i>	Espin

 **$\Sigma$  2144 *rej.* S.D.(7<sup>5</sup>) 4419. 7.6 ... 10.2**

R.A. =  $17^{\text{h}} 10^{\text{m}} 53^{\text{s}}$  /  
Decl. =  $-7^{\circ} 41'$  /

1901.375	182.8	25.65
.414	182.4	25.25
1901.39	182.6	25.45

The only other measure is a single observation by Mitchell,  $4^{\text{h}} 0' 25.73$  (1848.60). The angle should be reversed.

 **$\Sigma$  2149.**

R.A. =  $17^{\text{h}} 13^{\text{m}} 32^{\text{s}}$  /  
Decl. =  $6^{\circ} 18'$  /

1901.203	24.1	7.34
1902.430	24.8	7.42
1901.81	24.4	7.38

The previous measures of this pair are very discordant in distance, but there is probably no change since  $\Sigma$ , who found  $23^{\circ} 2' 7.47$  (1830.15).

 **$\sigma$  544. 72 *Herculis*. 5 ... 9.6**

R.A. =  $17^{\text{h}} 16^{\text{m}} 10^{\text{s}}$  /  
Decl. =  $+32^{\circ} 38'$  /

A and B

1900.473	332.6	207.33
.476	332.0	207.76

1900.47	332.3	207.54
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B and C (C = 12.5)

1900.473	216.1	8.64
.476	217.5	8.73

1900.47	216.8	8.68
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The change in B is due to the proper motion of A, 1.037 in  $17^{\text{h}} 11'$ . No other complete measures of C.

**H 4948. S.D.(22) 4341. 8.3 ... 9.8**

R.A. =  $17^{\text{h}} 17^{\text{m}} 9^{\text{s}}$  /  
Decl. =  $-22^{\circ} 41'$  /

1901.433	106.2	12.91
.455	105.2	13.37
.512	104.8	13.13

1901.47	105.4	13.14
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H 4851 has an error of  $1^{\text{h}}$  in the R.A. and is identical with the pair measured.

**O $\Sigma$  329 *rej.* (= S 688). L 31771**

R.A. =  $17^{\text{h}} 20^{\text{m}} 17^{\text{s}}$  /  
Decl. =  $-37^{\circ} 33'$  /

1900.458	12.7	32.74
1901.320	12.2	32.62

1900.89	12.4	32.68
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Without change.

**H 1299. L 31783. 7 ... 12 ... 12.5**

R.A. =  $17^{\text{h}} 21^{\text{m}} 12^{\text{s}}$  /  
Decl. =  $+26^{\circ} 59'$  /

A and B

1901.375	21.0	50.53
.395	19.9	50.78

1901.38	20.4	50.65
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## A and C

1901.375	57.5	52.69
.395	57.6	52.55

1901.38	57.5	52.62
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H gives for the angles  $20^{\circ}7$  and  $60^{\circ}5$  (1828).

$\Sigma$  2189 *rej.* 7.9 ... 10.3 ... 8.6

R.A. =  $17^{\text{h}}29^{\text{m}}37^{\text{s}}$  }  
Decl. =  $+47^{\circ}58'$  }

## A and B

1901.356	100.5	20.88
.375	100.0	21.06
.433	99.4	21.27

1901.39	100.0	21.07
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## A and C

1901.356	359.6	65.11
.375	359.2	64.96
.433	359.9	65.06

1901.39	359.6	65.04
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A and C are D.M.(48°)2532 and 2533. The only measures of AB are  $98^{\circ}5 : 20^{\circ}58$  (1900.53) 2*n* Espin.

## Hd Zones

R.A. =  $17^{\text{h}}32^{\text{m}}14^{\text{s}}$  }  
Decl. =  $+0^{\circ}56'$  }

Noted as "double" in Harvard Zones. The place is that of the 9.2m star, D.M.(0°)3739. It is not double.

Skinner. S.D.(15°)4651. 8.5 ... 9.0

R.A. =  $17^{\text{h}}35^{\text{m}}20^{\text{s}}$  }  
Decl. =  $-15^{\circ}40'$  }

1901.512	275.8	4.33
.586	276.0	4.29

1901.55	275.9	4.31
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Discovered by Skinner with the meridian circle of the Naval Observatory. It is also Hussey 184.

$\Sigma$  2195 *rej.* 9 ... 9

R.A. =  $17^{\text{h}}36^{\text{m}}13^{\text{s}}$  }  
Decl. =  $+21^{\circ}13'$  }

1901.414	101.3	21.60
.416	101.0	21.61

1901.41	101.1	21.60
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No other measures. In the field  $2'$  or  $3' p \approx 2196$ .

H 4986. O.Arg.S.17253 8.2 ... 11.2

R.A. =  $17^{\text{h}}42^{\text{m}}50^{\text{s}}$  }  
Decl. =  $-26^{\circ}18'$  }

1901.375	226.2	10.26
.433	226.7	11.04

.452	226.5	10.56
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1901.42	226.5	10.62
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No measures. H gives  $330^{\circ} \pm 12' \pm (1834.3)$ ; probably error of  $100^{\circ}$ . There is a 13m star  $5^{\circ}4 : 22^{\circ}9$ , and 12.5m at  $61^{\circ}4 : 27^{\circ}2$ .

 $\Sigma$  2230

R.A. =  $17^{\text{h}}44^{\text{m}}54^{\text{s}}$  }  
Decl. =  $+7^{\circ}57'$  }

## A and B

1900.458	108.8	37.52
.515	109.1	37.72

1900.48	108.9	37.62
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## A and C

1900.458	83.2	45.45
.515	84.3	45.50

1900.48	83.7	45.47
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## B and C

1900.458	208.5	19.26
.515	211.0	19.05

1900.48	209.7	19.15
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The principal star has a small proper motion of about  $0.017$ , which increases the distances of both companions.

H 4995. L 32695. 6.7 ... 11.7

R.A. =  $17^{\text{h}}47^{\text{m}}26^{\text{s}}$  }  
Decl. =  $-11^{\circ}19'$  }

1900.551	154.6	28.60
1901.263	156.1	28.48

1900.96	155.3	28.54
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H has  $140^{\circ} \pm 18' \pm$ ; "a third, closer, suspected." Neither this telescope nor the 18½-in. in 1878 showed any other companion.

$O\Sigma$  (App) 160. 8.2 ... 8.6

R.A. =  $17^{\text{h}}47^{\text{m}}46^{\text{s}}$  }  
Decl. =  $+10^{\circ}59'$  }

1900.458	190.8	102.30
.476	191.0	102.14

1900.46	190.9	102.17
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$\Delta$  did not find this, and there are no other measures. The components are D.M.(10°)3315 and 3314. The A.G. positions give  $191^{\circ}6 : 100^{\circ}87$ .

**Holden. L 32716. 6.7 ... 12**

	R.A. = $17^h 48^m 13^s$ }	
	Decl. = $-11^\circ 37'$ }	
1900.551	154.3	3.51
.553	150.0	3.56
1900.55	152.1	3.53

Discovered by Professor Holden at the Washburn Observatory. Unchanged.

**Bird. O.Arg.N.17688. 9 ... 10.5 ... 9**

	R.A. = $17^h 52^m 55^s$ }	
	Decl. = $+67^\circ 1'$ }	
	A and B	
1901.375	325.4	11.83
.433	326.3	11.65
1901.40	325.8	11.74
	A and C	
1901.375	328.5	22.28
.433	328.6	22.40
1901.40	328.5	22.34
	B and C	
1901.375	333.5	10.28
.433	331.9	10.35
1901.40	332.7	10.31

The wide pair AC "duplex" in O.Arg. The faint star between discovered by F. Bird in 1869. The only other measures are mine in 1879.

 **$\Sigma$  2253**

	R.A. = $17^h 52^m 55^s$ }	
	Decl. = $+14^\circ 38'$ }	
1901.203	78.4	15.22
.225	78.2	15.50
1901.21	78.3	15.36

Distance slowly decreasing.

 **$\text{O}\Sigma$  (A.P.P.) 161**

	R.A. = $17^h 51^m 29^s$ }	
	Decl. = $+8^\circ 52'$ }	
1901.375	76.7	62.36
.436	77.2	62.20
.471	76.8	62.27
1901.43	76.9	62.28

The only other measures are by A, 77.9 : 62.70 (1874.98) 3m.

**W<sup>1</sup> XVII. 1120**

R.A. = $17^h 55^m 22^s$ }
Decl. = $-14^\circ 30'$ }

"Duplex" in Weisse. This is S.D.(14°)4860, 8.7m  
Not double, and no near companion.

**S 698. L 33058. 7 ... 8**

R.A. = $17^h 56^m 57^s$ }
Decl. = $-22^\circ 30'$ }

1900.551	316.1	29.70
1901.263	317.0	29.52
1900.90	316.5	29.61

No other measures since South, 317.4 : 30.92 (1825.51) 2m. There are many stars in the field, and several nearer than B.

**H 5013. S.D.(15°)4801. 9.7 ... 11.7**

R.A. = $17^h 57^m 38^s$ }
Decl. = $-15^\circ 5'$ }

1901.455	338.4	13.31
.529	338.6	13.53
1901.49	338.5	13.42

The only observations by H, 339.7  $\pm$  .4 : 3.9 ... 13.

**A.C. 15. 99 *Herculis***

R.A. = $18^h 2^m 28^s$ }
Decl. = $+30^\circ 23'$ }

1898.269	317.5	1.04
.271	322.4	1.21
.463	320.8	1.19
1898.33	320.2	1.15

**Perry. 10.2 ... 11.0**

R.A. = $18^h 3^m 38^s$ }
Decl. = $+9^\circ 20'$ }

1900.551	313.1	3.28
1902.433	313.1	3.37
1901.49	313.1	3.32

Not in D.M. It is about 1<sup>m</sup>f D.M.(9°)3565. The only other observation is 305.0 : 2.0 (1881.38) Perry.

**Alvan G. Clark. 102 *Herculis*. 5.4 ... 12.9**

R.A. = $18^h 3^m 38^s$ }
Decl. = $+20^\circ 48'$ }

1900.458	135.9	23.66
.473	135.6	23.72
1901.455	136.5	23.28
1900.76	135.7	23.55

The only prior measures are mine,  $136^{\circ}7' : 23^{\circ}42'$  (1878.45)  $1n$ . This angle is erroneously printed  $46^{\circ}7'$ . The proper motion of A is small,  $0.015$  in  $212^{\circ}9$ .

**Σ 2285**

R.A. =  $18^{\text{h}} 3^{\text{m}} 45^{\text{s}}$  }  
Decl. =  $+13^{\circ} 28'$  }

1900.458	333.6	3.50
1901.203	333.2	3.45
1900.83	333.4	3.47

Without change. No late measures.

**H 593.** S.D.( $17^{\circ}$ )5052.  $8.2 \dots 11.5 \dots 9.5$ 

R.A. =  $18^{\text{h}} 3^{\text{m}} 48^{\text{s}}$  }  
Decl. =  $-17^{\circ} 10'$  }

A and C

1901.455	303.4	18.15
.512	301.1	18.08
1901.48	302.2	18.11

A and B (= Hussey 195)

1901.512	75.8	1.14
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Close pair discovered by Hussey in 1900. No other measures of H 593 except Glasenapp,  $300^{\circ}9' : 17^{\circ}26'$  (1890.54)  $2n$ .

**H 5030.** L 33330.  $6 \dots 10.8$ 

R.A. =  $18^{\text{h}} 4^{\text{m}} 24^{\text{s}}$  }  
Decl. =  $-23^{\circ} 44'$  }

1901.263	287.3	41.65
.586	287.3	42.24
1901.42	287.3	41.94

The only other measure is:

1834.3	$281^{\circ}0' : 30^{\circ}$	$1n$	H
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**H 2820.**  $9.5 \dots 10.7 \dots 10.8$ 

R.A. =  $18^{\text{h}} 4^{\text{m}} 45^{\text{s}}$  }  
Decl. =  $-18^{\circ} 26'$  }

A and B

1901.455	279.3	5.58
.529	278.3	5.72
1901.49	278.8	5.65

A and C

1901.455	82.7	12.87
.529	83.8	13.10
1901.49	83.2	12.98

The principal star is S.D.( $18^{\circ}$ )4826. The only other observations by H,  $281^{\circ}9' : 3^{\circ} \pm ; 90^{\circ}0' : 8^{\circ} \pm$  (1830).

**Σ 2291**

R.A. =  $18^{\text{h}} 5^{\text{m}} 53^{\text{s}}$  }  
Decl. =  $+34^{\circ} 0'$  }

1900.473	339.3	27.01
1901.299	339.0	26.85
.320	339.4	26.53
1901.03	339.2	26.80

No recent measures. Distance increasing?

1830.73	$339^{\circ}2' : 25^{\circ}12'$	$2n$	Σ
1868.02	$339.2 : 25.90$	$4n$	J

**H 1821.** S.D.( $16^{\circ}$ )4755.  $9.2 \dots 9.6$ 

R.A. =  $18^{\text{h}} 5^{\text{m}} 54^{\text{s}}$  }  
Decl. =  $-16^{\circ} 20'$  }

1901.529	$278^{\circ}0' : 8^{\circ}00'$
1902.433	$278.0 : 7.62$
1901.98	$278.0 : 7.81$

H has  $273^{\circ}6' : 4^{\circ} \pm$  (1828).

A and S.D.( $16^{\circ}$ )4756

1901.529	13.6	53.07
1902.433	13.4	53.25
1901.98	13.5	53.16

**H V. 93.** D.M.( $28^{\circ}$ )2955 and 2956

R.A. =  $18^{\text{h}} 8^{\text{m}} 17^{\text{s}}$  }  
Decl. =  $+28^{\circ} 13'$  }

1901.203	$136^{\circ}4' : 54^{\circ}97'$
.225	$136.4 : 54.43$
1901.21	$136.4 : 54.70$

The only measures are:

1783.65	$135^{\circ}7' : 47^{\circ}77'$	$1n$	H
1880.40	$136.4 : 54.88$	$3n$	β

The Weisse meridian positions give  $132^{\circ}9' : 54^{\circ}10'$  (1825). Bigourdan has measured another pair, or the distance is erroneous.

**H 857.** W<sup>1</sup> XVIII. 192.  $8 \dots 11$ 

R.A. =  $18^{\text{h}} 10^{\text{m}} 53^{\text{s}}$  }  
Decl. =  $-7^{\circ} 20'$  }

1901.452	$20^{\circ}3' : 21^{\circ}49'$
.509	$19.6 : 20.92$
1901.48	$20.0 : 21.20$

No other measures. H estimated  $20^{\circ} : 15^{\circ}$  (1820).

**H 5494.** B.A.C. 6213. 6...11.8

	R.A. = 18 <sup>h</sup> 13 <sup>m</sup> 20 <sup>s</sup> $\frac{1}{2}$	
	Decl. = - 7 12 $\frac{1}{2}$	
1901.416	69.5	39.07
.509	70.0	39.79
.512	70.0	39.60
1901.48	69.8	39.49

Only the estimates of H, 65 : 45 : 5...15 (1827.6).

**O. Stone**

R.A. = 18 <sup>h</sup> 16 <sup>m</sup> $\frac{1}{2}$
Decl. = - 18 55 $\frac{1}{2}$

Given in Cin<sup>6</sup> with this place, 84°6 : 6°72 : 8.5...9.0 (1879.30). No such pair in or near this place. A plenty of faint pairs of one kind and another, but nothing answering this description (1901.452). The place is certainly erroneous.

**Σ 2311**

	R.A. = 18 <sup>h</sup> 16 <sup>m</sup> 38 <sup>s</sup> $\frac{1}{2}$	
	Decl. = - 11 23 $\frac{1}{2}$	
1900.512	158.8	5.65
.515	159.1	5.72
1900.51	159.0	5.68

The motion appears to be rectilinear.

1830.30 170.7 8°65 4*a* Σ

These positions give for the proper motion of A 0.047 in 191.2.

**H 5496.** L 34034

R.A. = 18 <sup>h</sup> 20 <sup>m</sup> 40 <sup>s</sup> $\frac{1}{2}$
Decl. = - 8 7 $\frac{1}{2}$

Given in H as 6*m* star, "suspected double with 180." I could not see any companion with the 6-in. in 1876, nor with the 40-in., 1901.455.

**H N. 125.** L 34018. 8.0...8.1

	R.A. = 18 <sup>h</sup> 21 <sup>m</sup> 33 <sup>s</sup> $\frac{1}{2}$	
	Decl. = - 25 7 $\frac{1}{2}$	
1901.551	281.3	2.67
.647	282.2	2.75
1900.60	281.7	2.71

No measures by H; given as Class I. The following are all the measures; distances discordant:

1889.77	293.0	1°62	1 <i>a</i>	H <sub>0</sub>
1897.70	401.8	3.44	2 <i>a</i>	See

**Σ 2332** *rej.* 9.2...11.2

	R.A. = 18 <sup>h</sup> 24 <sup>m</sup> 42 <sup>s</sup> $\frac{1}{2}$	
	Decl. = + 64 50 $\frac{1}{2}$	
1901.433	262.5	10.71
.436	263.7	11.89
.452	262.3	10.93
1901.44	262.8	11.18

No other measures. Not in D.M., but near D.M. (64°)1267, the place of which is given here.

**Schjellerup.** D.M.(7°)3741. 8.9...9.0

	R.A. = 18 <sup>h</sup> 27 <sup>m</sup> 49 <sup>s</sup> $\frac{1}{2}$	
	Decl. = + 7 21 $\frac{1}{2}$	
1901.509	197.7	46.02
.512	197.6	45.64
1901.51	197.6	45.83

From list of new pairs in A.N. 1485, the distance given 34". No other measures. Both stars in D.M. There is a 13.5*m* star from A, 119° : 14.5.

**Σ 2340**

	R.A. = 18 <sup>h</sup> 28 <sup>m</sup> 30 <sup>s</sup> $\frac{1}{2}$	
	Decl. = + 31 30 $\frac{1}{2}$	
1901.433	103.9	23.02
.436	103.3	23.20
.452	103.7	23.06
1901.44	103.6	23.09

The change appears to be due to a small proper motion of one of the stars.

1830.43 104°6 21.51 3*a* Σ

**OΣ 356** *rej.* L 34475

	R.A. = 18 <sup>h</sup> 29 <sup>m</sup> 20 <sup>s</sup> $\frac{1}{2}$	
	Decl. = + 40° 4' $\frac{1}{2}$	
1900.473	305.9	36.11
1901.225	306.2	35.98
1900.85	306.0	36.04

Distance slowly decreasing from proper motion. Other recent measures by Hussey.

**Σ 2345**

	R.A. = 18 <sup>h</sup> 30 <sup>m</sup> 23 <sup>s</sup> $\frac{1}{2}$	
	Decl. = + 20° 59' $\frac{1}{2}$	
1901.436	203.8	8.58
.452	204.0	8.53
1901.44	203.9	8.55

Rectilinear motion. Σ found 1857.1 : 7.38 (1832.25) 4*n*.

**Σ 2346**

R.A. =  $18^h 31^m 27^s$  }  
Decl. =  $+ 7^\circ 26'$  }

1901.471	291.8	21.17
.586	291.2	21.19
1901.53	291.5	21.18

The motion is rectilinear, distance and angle increasing.

1829.64    282.9    15.41    4*n*    Σ

These measures give for the proper motion of A 0.091 in 132.5.

**Σ 2353 rej.** D.M.(58°)1823. 8.5 . . . 11

R.A. =  $18^h 31^m 36^s$  }  
Decl. =  $+ 58^\circ 41'$  }

1901.299	258.5	13.98
.318	258.8	13.76
1901.31	258.6	13.87

The only measures of this are found in the introduction to *Mens. Microm.*, 258.7 : 13.2 (1832.8). D.M.(58°)1824, which is 4.4*s*, is a similar pair with a little less distance.

**O.Arg.S.18506.** 8 . . . 8.4 . . . 10.3

R.A. =  $18^h 32^m 28^s$  }  
Decl. =  $- 25^\circ 37'$  }

A and B

1901.529	216.9	7.36
1902.449	217.1	7.22
1901.98	217.0	7.29

A and C

1901.529	285.7	53.27
1902.449	286.3	52.97
1901.98	286.0	53.12

A and D

1901.529	217.4	80.78
1902.449	217.9	80.14
1901.98	217.6	80.46

Noted "duplex" in O.Arg.S. and "triple" in Washington Transit Zones. The first measures from Washington Observations, 1862, do not agree with the present positions :

1862.8	212.8	7.47
1862.8	285.2	68.66
1862.8	218.5	79.02

**H IV. 59 = Σ 2354 rej.** 8.5 . . . 9.0

R.A. =  $18^h 32^m 45^s$  }  
Decl. =  $+ 38^\circ 38'$  }

1900.473	302.1	29.52
1901.225	302.7	29.40
1900.85	302.4	29.46

Near *Vega*. The only other measures are :

1783.81	303.9	22.33	1 <i>n</i>	H
1880.42	303.6	29.80	2 <i>n</i>	β

**Σ 2350 rej.** L 34569. 6.7 . . . 11

R.A. =  $18^h 33^m 30^s$  }  
Decl. =  $- 7^\circ 54'$  }

1901.395	196.4	22.16
.452	196.1	22.18
1901.42	196.2	22.17

The only measures are :

1848.64	194.8	24.54	1 <i>n</i>	Mitchell
1880.02	196.8	23.27	2 <i>n</i>	β

**Σ 2365 rej.** 8.3 . . . 10.0

R.A. =  $18^h 34^m 21^s$  }  
Decl. =  $+ 63^\circ 36'$  }

1901.433	26.1	19.58
.436	24.5	19.84
1901.43	25.3	19.70

No other measures. The principal star has a proper motion of 0.282 in 193.2 (Porter). The movement in A.G. is 0.306 in 189.3. This is D.M. (63°)1439 (= Groombridge 2630).

**H 1336.** 8.2 . . . 11.5 . . . 11

R.A. =  $18^h 35^m 52^s$  }  
Decl. =  $+ 30^\circ 11'$  }

A and B

1901.263	87.4	17.59
.302	86.7	17.62
1901.28	87.0	17.60

A and C

1901.302	176.7	32.25
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The only other observation is by H, 89.0 : 8° ± ; 300° ± : 15° ± (1828). There is another 11*m* star, 295.9 : 32.6. Σ 2367 is 47*f*.

**Ho 437**

R.A. =  $18^h 35^m 58^s$  }  
Decl. =  $+ 31^\circ 32'$  }

AB and C

1901.436	272.1	39.61
.452	273.2	40.02
1901.44	272.6	39.81

C and D		
1901.436	335.8	3.08
.452	336.5	3.48
1901.44	336.1	3.28

Seeing too poor for AB.

**H 1337.** D.M.(31°)3330. 9.0 ... 11.6

R.A. = $18^h 36^m 22^s$ }		
Decl. = $+31^\circ 23'$ }		
1901.436	162.4	9.08
.452	162.5	9.00
1901.44	162.4	9.04

Observations of H only:

1828	174.9	6	1n
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**D.M.(45°)2667.** 8.9 ... 12.5 ... 9.9.

R.A. = $18^h 41^m 12^s$ }		
Decl. = $+45^\circ 43'$ }		
A and B		
1901.263	132.4	2.66
.299	131.7	3.15
.302	132.0	3.02
1901.29	132.0	2.94

A and C (= H 1346)

1901.263	216.8	24.38
.299	216.1	24.28
.302	216.4	24.45
1901.29	216.4	24.37

B is not in H, and was first noted by Espin (A.N. 3717), who found  $135^\circ 9' 2.73$  (1900.62) 2n.

**H VI. 50.** 6.4 ... 12.5 ... 8

R.A. = $18^h 43^m 15^s$ }		
Decl. = $-6^\circ 3'$ }		
A and B		
1901.397	359.4	22.83
.452	360.3	23.30
.471	361.2	23.49
1901.44	360.3	23.21

A and C

1901.397	170.6	113.75
.452	171.0	113.53
.471	170.7	113.98
1901.44	170.8	113.75

The small star B was first noted with the 6-in.

The only measures are:

1879.37	356.8	22.53	1n	$\beta$
1879.35	170.5	113.98	2n	$\beta$

A and C are S.D.(6°)4922 and 4923.

**H 1353.** D.M.(11°)3654. 9.0 ... 9.6

R.A. = $18^h 48^m 42^s$ }		
Decl. = $+11^\circ 9'$ }		
1901.359	208.0	8.41
.397	206.6	8.26
1901.38	207.3	8.33

The only measures are:

1828	212.2	5	1n	H
1879.45	208.1	8.41	2n	Cin

Howe (Cin<sup>o</sup>) has a close pair in this place, 209<sup>o</sup>1: 0.94 (1879.31) 1n. There is no close double here, and it is undoubtedly an error in reading or printing the distance.

**Lewis**

R.A. = $18^h 50^m$ }	
Decl. = $+34^\circ 30'$ }	

This pair has the above place for 1900 (*Mon. Not.*, LX, 510) with the following measure:

1899.44	84.6	5.13	8.0 ... 10.0	1n
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The place is substantially identical with that of the 7.9m star, D.M.(34°)3346. This star was examined on two nights, and the stars in the vicinity as well, but no pair found to answer the description.

 **$\beta$  647**

R.A. = $18^h 50^m 29^s$ }	
Decl. = $+13^\circ 27'$ }	

A and B

1900.512	16.1	1.07
.515	14.6	0.87
1900.51	15.3	0.97

A and C

1900.512	217.3	19.01
.515	217.6	19.03
1900.51	217.4	19.02

Change in the distance of C is confirmed by these measures.

 **$\beta$  648**

R.A. = $18^h 52^m 30^s$ }	
Decl. = $+32^\circ 45'$ }	

1900.473	215.3	1.24
.553	225.6	1.40
.703	229.9	1.37
1901.203	218.3	1.07
1900.73	222.3	1.27

**H 1357.** D.M.(45°)2799. 8.0 . . . 10.5

R.A. =  $18^h 53^m 34^s$  }  
 Decl. =  $+ 45^\circ 42'$  }

1901.433	213.2	26.75
.452	211.9	26.92
1901.44	212.5	26.83

The only prior measures are:

1828+ 210.8 16"± 1n H

**Σ 2427**

R.A. =  $18^h 53^m 57^s$  }  
 Decl. =  $+ 38^\circ 4'$  }

A and B

1900.473	61.3	48.54
1901.225	61.8	48.55
1900.85	61.5	48.54

B and C

1900.473	79.3	7.04
1901.225	78.9	7.32
1900.85	79.1	7.18

No change in BC, but the distance of AB is increasing. A comparison of these measures with Σ's gives for the proper motion of A 0.064 in the direction of 41°.

**A.G.C. 9. γ Lyrae**

R.A. =  $18^h 54^m 27^s$  }  
 Decl. =  $+ 32^\circ 31'$  }

1900.515	298.9	12.87
.551	299.9	12.91
1901.210	300.1	12.69
1900.76	299.6	12.82

**H 874.** 7.1 . . . 13.3 . . . 11.7

R.A. =  $18^h 54^m 35^s$  }  
 Decl. =  $- 0^\circ 37'$  }

A and C

1901.395	304.2	23.01
.397	304.6	22.92
.455	303.9	22.94
1901.41	304.2	22.96

A and B (new)

1901.395	2.4	9.30
.397	0.4	10.05
.455	359.0	9.74
1901.41	0.6	9.70

No other measures. H estimated  $305^\circ : 15'$ . The principal star is W<sup>1</sup> XVIII. 1351.

**H 2852.** D.M.(7°)3943. 9.1 . . . 9.9

R.A. =  $18^h 57^m 16^s$  }  
 Decl. =  $+ 7^\circ 14'$  }

1901.512	131.2	22.63
.586	131.4	22.41
1901.55	131.3	22.52

H called the components *red* : *blue-green*;  $134^\circ 5' : 18^\circ \pm : 10 \dots 12$  (1830).

**Σ 2442**

R.A. =  $18^h 58^m 20^s$  }  
 Decl. =  $+ 16^\circ 48'$  }

1901.299	207.5	18.37
.703	205.4	18.20
1901.50	206.4	18.28

The distance is decreasing, with no sensible change in the angle. These measures with those of Σ indicate an annual movement of A of 0.06 in the direction of the smaller star. In the course of some three hundred years these stars will make a close pair.

**H V. 33.** 15 *Aquilae*. 6 . . . 8

R.A. =  $18^h 58^m 38^s$  }  
 Decl. =  $- 4^\circ 13'$  }

1900.458	208.4	37.05
.473	208.2	37.42
1900.46	208.3	37.23

The proper motion of A is very small, 0.014 in 300.3. The distance of H in 1781 of 33.88 is certainly too small.

**H 5507.** 6 . . . 12.2

R.A. =  $18^h 58^m 49^s$  }  
 Decl. =  $- 15^\circ 50'$  }

1900.458	63.0	47.10
1901.397	63.3	46.76
1900.92	63.1	46.93

H only estimated the angle  $50^\circ$  (1823.6). There is a 14m star about the same distance in  $94^\circ 8'$ .

**H 1364.** D.M.(44°)3051. 9.4 . . . 9.4

R.A. =  $18^h 59^m 36^s$  }  
 Decl. =  $+ 44^\circ 17'$  }

1901.452	204.7	3.13
1902.433	207.7	2.98
1901.94	206.2	3.05

Described by H, "a most elegant double star; chief of a small cluster." The only observations are:

1828+	204°5	1'±	1 <i>m</i>	H
1881.45	206.9	3.26	3 <i>m</i>	$\beta$

**H 1365.** D.M.(26) 8443. 9.5...11

R.A. = 19<sup>h</sup> 0<sup>m</sup> 22<sup>s</sup> }  
Decl. = + 26° 57' }

1901.452	326.6	20.67
1902.219	325.1	20.04
1901.83	325.8	20.35

H has 327°5 : 15'± (1828), and calls the colors *ruddy* : *green*.

**H V. 103.** L 35845. 8.0...8.3

R.A. = 19<sup>h</sup> 1<sup>m</sup> 42<sup>s</sup> }  
Decl. = + 35° 42' }

1901.225	55.3	55.66
.299	55.5	55.62
1901.26	55.4	55.64

The only measures are:

1783.63	60°6	45.53	1 <i>m</i>	H
1840.83	55.6	54.58	1 <i>m</i>	$\alpha\Sigma$
1866.68	55.5	55.08	1 <i>m</i>	$\alpha\Sigma$

**$\Sigma$  2463.** D.M.(45°)2831

R.A. = 19<sup>h</sup> 2<sup>m</sup> 30<sup>s</sup> }  
Decl. = - 45° 38' }

A and B

1901.529	5.1	9.44
.605	5.7	9.49
1901.57	5.4	9.46
A and C		
1901.529	283°0	23.52
.605	282.4	23.96
1901.57	282.7	23.74

C not in  $\Sigma$ ; first noted by H, who gave the angle 279.9 and 286.4 (1828). No other measures of this.

**$\Sigma$  2477 *rej.*** 8.5...10.5

R.A. = 19<sup>h</sup> 6<sup>m</sup> 2<sup>s</sup> }  
Decl. = - 4° 40' }

1901.452	47.4	28.08
.455	46.3	27.87
.471	45.9	27.92
1901.46	46.5	27.96

The only prior measures are:

1848.65	45.3	30.10	1 <i>m</i>	Mitchell
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**H 1374.** L 36113. 8.0...11.7...13.5

R.A. = 19<sup>h</sup> 6<sup>m</sup> 34<sup>s</sup> }  
Decl. = + 44° 22' }

A and B

1901.263	115.1	14.28
.318	114.3	14.41
1901.29	114.7	14.34

A and C

1901.263	5°9	31.34
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The description in H is 110°3 : 8'±; 350°± : 15'±.

**Schjellerup.** 8.5...8.8

R.A. = 19<sup>h</sup> 6<sup>m</sup> 40<sup>s</sup> }  
Decl. = - 3° 45' }

1901.452	230°4	61.16
.455	230.2	61.02
1901.45	230.3	61.09

From list of double stars in A.N. 1485. The estimated distance is given 48". The components are S.D.(3°)4513 and 4511.

**Madler 7 = Ho 446**

R.A. = 19<sup>h</sup> 7<sup>m</sup> 43<sup>s</sup> }  
Decl. = + 24° 23' }

A and B (new)

1901.433	292°4	2.79
.473	288.6	2.56
.512	291.0	2.82
1901.47	290.7	2.72

A and C

1901.416	50°0	5.01
.433	50.6	5.01
.473	45.2	5.21
.512	48.8	5.17
1901.46	48.6	5.10

B is new, but previously seen by Aitken. The measures of AC are:

1813.63	58.3	8.69	1 <i>m</i>	Ma
1893.67	45.4	5.69	3 <i>m</i>	Ho

The principal star is W<sup>2</sup> XIX. 193.

**H 2858.** 9.2...12.2

R.A. = 19<sup>h</sup> 8<sup>m</sup> 46<sup>s</sup> }  
Decl. = + 22° 38' }

1901.436	257°4	18.99
1902.219	257.9	19.06
1901.82	257.6	19.02

H gives 257°6 : 6'± (1830).

**H 2859.** 9.2...13

R.A. =  $19^{\text{h}} 8^{\text{m}} 47^{\text{s}}$  }  
 Decl. =  $+22^{\circ} 40'$  }

1901.436	28.3	10.87
1902.219	28.8	11.53
1901.82	28.5	11.20

H gives  $19^{\circ}0:4' = (1830)$ . The relation of H 2858 and 2859 is  $10^{\circ}2:132^{\circ}70$  (1901.43).

**H 1377.** L 36224. 7.0...12.9

R.A. =  $19^{\text{h}} 8^{\text{m}} 51^{\text{s}}$  }  
 Decl. =  $+47^{\circ} 10'$  }

1901.436	356.5	36.33
.605	357.1	36.35
1901.52	356.8	36.34

The only other observation is by H,  $357^{\circ}0:30' \pm 7 \dots 16$  (1828).

**H 5101.** 8.5...9

R.A. =  $19^{\text{h}} 9^{\text{m}} 2^{\text{s}}$  }  
 Decl. =  $-25^{\circ} 33'$  }

1901.586	306.3	21.32
.720	306.9	20.97
1901.65	306.6	21.14

Both components in Cord.D.M. as Nos. 13881 and 13879. H found  $311^{\circ}5:20' \pm (1837.2)$ .

**H 1376.** 8.0...11.2

R.A. =  $19^{\text{h}} 9^{\text{m}} 4^{\text{s}}$  }  
 Decl. =  $+15^{\circ} 10'$  }

1901.416	121.6	10.16
.471	123.6	10.14
1901.44	122.6	10.15

H gives  $120^{\circ}4:6' \pm (1828)$ .

**OΣ 366** *rej.* 7.5...9.2

R.A. =  $19^{\text{h}} 9^{\text{m}} 48^{\text{s}}$  }  
 Decl. =  $+34^{\circ} 0'$  }

1901.471	230.2	22.14
.589	229.6	21.74
1901.53	229.9	21.94

Without change. The principal star is L 36242. Two faint stars *s* and *sf*.

**OΣ (App) 178.** 6...7.5

R.A. =  $19^{\text{h}} 9^{\text{m}} 52^{\text{s}}$  }  
 Decl. =  $+14^{\circ} 53'$  }

1900.684	267.8	89.91
.687	267.4	89.83
1900.68	267.6	89.87

The following are all the other measures:

1856.60	86.7	80.84	1 <i>n</i>	Se
1875.61	267.8	89.65	4 <i>n</i>	<i>d</i>

The change is not confirmed. The distance of Secchi is an error or misprint. The A.G. positions give  $268^{\circ}0:89.68$ . The components are L 36207 and 36203.

**H 2862.** 1 *Vulpeculae*

R.A. =  $19^{\text{h}} 11^{\text{m}} 3^{\text{s}}$  }  
 Decl. =  $+21^{\circ} 11'$  }

1901.416	13.2	38.86
.512	12.6	39.16
.586	12.8	39.08
1901.50	12.9	39.07

The only other measure is by H:

1830+  $10^{\circ}6:25' \pm 5.6 \dots 17$

There is a 13*m* star,  $158^{\circ}2:43.5$ .

**H 2863.** B.A.C. 6590. 6.2...11.7

R.A. =  $19^{\text{h}} 12^{\text{m}} 10^{\text{s}}$  }  
 Decl. =  $-15^{\circ} 44'$  }

1900.458	16.0	45.96
.551	16.6	45.67
1900.50	16.3	45.81

H gives  $14^{\circ}6:15' \pm 6 \dots 15$  (1830); "a third *np* very strongly suspected." I could not see any third star with the 6-in. in 1874, and the 40-in. shows nothing now. The principal star has a proper motion of  $0^{\circ}293$  in  $204^{\circ}7$ .

**H 266.** 10.2...10.6

R.A. =  $19^{\text{h}} 13^{\text{m}} 8^{\text{s}}$  }  
 Decl. =  $-1^{\circ} 47'$  }

1901.529	266.2	14.57
.586	265.1	14.55
1901.56	265.6	14.56

This is not in the D.M., but is closely *f* D.M. ( $-1^{\circ}$ ) 3706. H has  $265^{\circ} \pm 5' \pm (1820)$ ; "a suspected stel-

lar nebula in the field." The 40-in. shows this as a double nebula, with the appearance of belonging to the planetary class. It was rediscovered by Marth, and is No. 6778 of Dreyer.

**$\Sigma$  2494 *rej.* 7.4 . . . 9.5**

R.A. = $19^h 13^m 36^s$ }		
Decl. = $- 6^{\circ} 51'$ }		
1900.458	81.1	25.26
1901.703	81.2	25.33
1901.08	81.1	25.29

There is an error of  $180^\circ$  in the angle of the only other measure:

1848.65	256.2	26.59	1 <i>m</i>	Mitchell
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**$\Sigma$  2500 *rej.* D.M.(19)3976. 8.0 . . . 10.5**

R.A. = $19^h 14^m 11^s$ }		
Decl. = $+ 19^{\circ} 30'$ }		
1901.416	24.3	19.74
.586	23.2	20.06
1901.50	23.7	19.90

No other measures except angle by H,  $23^\circ 0'$  (1830). The A.G. proper motion of A. is  $0.062$  in  $280^\circ 2'$ .

The 6.8*m* star, distant about  $10''$  *sp.*, D.M.(19)3975, is said to be an Algol variable, the magnitude descending to 9*m*, with a period of about 17 days (A.N. 3748).

**$O\Sigma$  (App) 180. L 36460. 7.7 . . . 8.0**

R.A. = $19^h 15^m 11^s$ }		
Decl. = $+ 14^{\circ} 12'$ }		
1900.684	266.5	80.40
.687	266.3	80.20
1900.68	266.4	80.30

The only measures are:

1874.98	265.3	80.22	3 <i>m</i>	J
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**H 884. 7.5 . . . 10.9 . . . 11.0**

R.A. = $19^h 15^m 28^s$ }		
Decl. = $- 9^{\circ} 36'$ }		
A and B		
1901.471	299.2	45.05
.586	299.7	44.59
1901.53	299.4	44.82

**B and C**

1901.471	236.7	10.48
.586	239.2	10.46
1901.53	237.9	10.47

No other measures. The principal star is D.M. (9°)4075.

**$\Sigma$  2501**

R.A. = $19^h 15^m 42^s$ }		
Decl. = $- 4^{\circ} 58'$ }		
1901.452	22.4	19.82
.455	21.7	20.05
1901.45	22.0	19.93

Without change. There is a 13.5*m* star from A.  $108^\circ 3' 9.6''$ .

**$\Sigma$  2506 *rej.* 8.7 . . . 9.1**

R.A. = $19^h 16^m 14^s$ }		
Decl. = $+ 14^{\circ} 8'$ }		
1901.589	350.5	16.63
.720	351.2	16.60
1901.65	350.8	16.61

Rejected by  $\Sigma$  as not subsequently found. Evidently fixed. A is D.M.(14°)3888. The only measures are:

1843.60	170.9	16.33	1 <i>m</i>	Ma
1875.01	351.3	16.43	2 <i>m</i>	J

**Glazenapp. S.D.(14°)5425. 9.0 . . . 9.5**

R.A. = $19^h 18^m 2^s$ }		
Decl. = $- 14^{\circ} 52'$ }		
1901.605	68.1	24.33
1902.449	66.7	24.28
1902.03	67.4	24.30

The only other measures are:

1890.54	69.2	23.99	2 <i>m</i>	Glazenapp
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**Schjellerup. 8.2 . . . 9.2**

R.A. = $19^h 19^m 33^s$ }		
Decl. = $+ 4^{\circ} 36'$ }		
1901.589	214.0	41.24
.720	214.2	41.18
1901.65	214.1	41.21

From list of new pairs in A.N. 1485. No other measures. A is D.M.(4°)4096.

**Σ 2517 rej.** D.M.(22°)3687. 8.7...9.7

R.A. =  $19^h 19^m 40^s$  }  
Decl. =  $+22^\circ 32'$  }

1901.589	138.6	15.85
.760	138.5	15.88
1901.67	138.5	15.86

No other measures.

**O. Stone**

R.A. =  $19^h 20^m$  : }  
Decl. =  $-16^\circ 11'$  }

Given in Cin<sup>5</sup>,  $195.4:4.84:6.8 \dots 7.3$  (1880.62)  
1m. I could not find any such pair in or near this place. There is no bright star here in the S.D.

**H 2871.** 4 *Vulpeculae*. 6...11.0

R.A. =  $19^h 20^m 12^s$  }  
Decl. =  $+19^\circ 34'$  }

1901.473	106.5	24.89
.512	106.3	24.89
1901.49	106.4	24.89

H gives  $110.4:30^\circ \pm$  (1890); "two more near; one extraordinarily faint." There is a star of about the same magnitude in 197.9 at about double the distance, and a 13.5m star, more distant, in 231.4.

**ν *Aquilae***

R.A. =  $19^h 20^m 23^s$  }  
Decl. =  $+0^\circ 6'$  }

1901.416	287.9	200.50
.433	288.2	200.74
1901.42	288.0	200.62

Measured in looking for H IV. 34, which is about 3<sup>m</sup>f. B is D.M.(0°)4204. The proper motion of A is 0.024 in 359.7 The A.G. positions give  $288.6:201.4$ . Many small stars nearer A than this.

**3 *Cygni*.** 6.5...10.4

R.A. =  $19^h 20^m 28^s$  }  
Decl. =  $+24^\circ 32'$  }

1900.515	78.3	30.94
.553	76.9	30.47
1901.473	76.2	30.21
1900.85	77.1	30.54

The principal star has a large proper motion, 0.658 in 198.1 (Berlin A.G.). The only other measures are by 02, the first of which is:

1866.72    122.8    27.91    1m    02

**H N. 119.** 6...8.2

R.A. =  $19^h 22^m 27^s$  }  
Decl. =  $-27^\circ 14'$  }

1901.455	141.9	7.65
.509	141.3	7.87
1901.48	141.6	7.76

No measures in H. There is an error of about 23' in his Decl. The measures of this show no change. It was measured by me in looking for No. 153 of the Harvard list, which has an error of about 3<sup>m</sup> R.A. and 10' in Decl. It is identical with the H pair.

**H 887.** L 36791. 7.0...13.2

R.A. =  $19^h 22^m 54^s$  }  
Decl. =  $-7^\circ 17'$  }

1900.473	348.7	35.54
.476	348.7	35.08
1900.47	348.7	35.31

No other measures. H called the small star 20m. The principal star appears to be the variable U *Aquilae*.

**H IV. 33.** 9.5...9.7

R.A. =  $19^h 23^m 9^s$  }  
Decl. =  $0^\circ 0'$  }

1901.433	335.7	12.96
.512	335.7	13.12
1901.47	335.7	13.04

H describes this as "the first of 2 stars *p ν Aquilae*; distance of the two nearest 21.98, inaccurate." After a very careful examination, I am certain that the star which he calls *ν Aquilae* is really the 6.9m star, D.M.(-0°)3760, which follows the other 2<sup>m</sup> 47. The description then applies perfectly. This faint pair is not in the D.M. The place given above is that of the bright star.

**02(σ *App*) 182.** 6.9...7.4

R.A. =  $19^h 23^m 37^s$  }  
Decl. =  $+49^\circ 54'$  }

1901.471	305.6	72.03
.509	305.4	71.67
.529	305.8	71.69
1901.50	305.6	71.80

The only other measures are:

1874.62    307.3    71.79    3m    4

There is a 14m star from A 113°9; 12°47 (1901.53) 1 $\alpha$ . There is also a small nebula in the field; from A in the direction of 247°3, and from B in 221°0. The principal star is given a proper motion of 0'085 in 54.3.

J 20. 7...10.1...9.7

R.A. = 19<sup>h</sup> 25<sup>m</sup> 1<sup>s</sup> }  
Decl. = - 2° 22' }

A and B

1901.589	65.2	1'48
.760	68.9	1.22
1901.67	67.0	1.35

A and C (=  $\Sigma$  2535)

1901.589	298°7	25'98
.604	297.9	25.94
.760	298.7	25.90
1901.65	298.4	25.94

No material change.

H 5128. 8.4...10.1...10.3

R.A. = 19<sup>h</sup> 26<sup>m</sup> 36<sup>s</sup> }  
Decl. = - 18° 52' }

A and B

1901.589	111.0	20'88
.604	111.4	21.08
1901.59	111.2	20.98

B and C

1901.589	125°5	4'29
.604	127.1	4.17
1901.59	126.3	4.23

No other measures of BC except an angle by H of 125°9 (1896.5). The single measure of AB of 1879 in Cin° shows no change. A and B are S.D.(18) 5413 and 5414.

Howe. 8.8...10.7...10.1

R.A. = 19<sup>h</sup> 29<sup>m</sup> 36<sup>s</sup> }  
Decl. = - 3° 12' }

A and B

1901.589	23°3	6'75
.742	25.6	6.81
1901.66	24.4	6.78

A and C

1901.589	306°7	32'50
.742	305.6	32.29
1901.66	306.1	32.39

Discovered by Howe, but the place in Cin° is in error in both R.A. and Decl. The only measures are those by him in 1879, which show no motion. The principal star in D.M.(3°)4079.

H V. 104. 7.3...9.8

R.A. = 19<sup>h</sup> 30<sup>m</sup> 55<sup>s</sup> }  
Decl. = + 15° 37' }

1901.433	126°6	39'08
.436	126.3	38.56
.471	125.4	38.82
1901.45	126.1	38.82

The place is a little uncertain in H. The principal star is D.M.(15°)3877. The magnitude in D.M. is 6.7. The only other measures, except position angle of 106°3 (1783.65), are:

1893.55 124°9 39'27 1 $\alpha$  Bigourdan

$\epsilon$  Sagittae

R.A. = 19<sup>h</sup> 31<sup>m</sup> 51<sup>s</sup> }  
Decl. = + 16° 12' }

1901.433	81°9	89'78
.471	81.3	89.71
.473	80.9	89.96
1901.46	81.4	89.82

As a wide pair this is H VI. 26 - H VI. 63 - H N. 83 = S 721 - 0 $\Sigma$  (App) 185. In H VI. 63 the angle is reversed. H N. 83 is given 3 $\alpha$ p and 11's, but it is identical with this star. The A.G. proper motion of A is very small, 0'013 in 297°5.

1782.30	81.5	91'87	1 $\alpha$	H
1800	79.9	87.86		Lakunde
1870.2	81.1	91.57		A.G.
1875.61	81.3	90.68	4 $\alpha$	J

H 1423. 9 Cygni. 6.5...11.2

R.A. = 19<sup>h</sup> 32<sup>m</sup> 22<sup>s</sup> }  
Decl. = + 29° 5' }

1900.473	127.8	20'85
.687	129.4	21.15
1900.58	128.6	21.00

Only H. 136°3; 12' (1828). The proper motion is insensible, 0'021 in 158°5 (Auwers).

**OΣ 379 rej.** 8.0 ... 8.5

R.A. =  $19^h 33^m 55^s$  }  
Decl. =  $+ 33^{\circ} 38'$  }

1900.703	86.4	24.97
1901.260	86.7	24.89
1900.98	86.5	24.93

Without change.

**H II. 32 = H N. 84.** 6.5 ... 8.6

R.A. =  $19^h 34^m 0^s$  }  
Decl. =  $+ 16^{\circ} 18'$  }

1900.473	300.9	28.46
.553	301.8	28.57
1900.51	301.3	28.51

The only measures are:

1796.59	301.8	27.20	1n	H
1840.22	302.2	28.61	2n	OΣ

**H 2888.** 45 *Aquilae*. 6.5 ... 13.7

R.A. =  $19^h 34^m 33^s$  }  
Decl. =  $- 0^{\circ} 54'$  }

1900.476	354.2	42.89
.515	355.4	42.23
1900.49	354.8	42.56

No observations except H, 354.5:30':7...19 (1890). His description is: "A large star in a constellation of at least a dozen small ones within 2' distance; that taken forms with the large star a good representation of the *Georgium Sidus* and one of its satellites. It is a fair comparison in point of light."

**O. Stone**

R.A. =  $19^h 35^m$  }  
Decl. =  $+ 37^{\circ} 55'$  }

The measures in Cin<sup>3</sup> are 224.1:5.06; 9.5...11.0 (1879.61) 1n. I could not find anything in this vicinity to correspond with the description, though there are many faint pairs. One near this place is 64.7:7.54.

**Σ 2560 rej.** L 37406. 7.2 ... 9.5

R.A. =  $19^h 35^m 34^s$  }  
Decl. =  $+ 23^{\circ} 26'$  }

1901.605	295.0	15.12
.760	295.1	15.48
1901.68	295.0	15.30

No other measures.

**H 895.** 8.7 ... 10.5 ... 9.1

R.A. =  $19^h 36^m 46^s$  }  
Decl. =  $+ 0^{\circ} 58'$  }

A and B

1901.433	209.0	14.17
.473	205.8	13.99
.512	208.3	14.39
1901.47	207.7	14.18

A and C

1901.433	17.5	28.50
.473	16.4	28.65
.512	16.6	28.43
1901.47	16.8	28.53

C and D (new). C = 13.7

1901.433	125.1	4.66
.512	123.3	4.52
1901.47	124.2	4.59

No measures by H. He saw only the three brighter stars. A and C are D.M.(0°)4283 and 4284.

**OΣ 381 rej.** 7.2 ... 11.7

R.A. =  $19^h 37^m 23^s$  }  
Decl. =  $+ 3^{\circ} 53'$  }

1900.476	5.7	15.04
.515	6.5	15.16
.551	5.7	15.20
1900.51	6.0	15.13

Unchanged.

**W<sup>1</sup> XIX. 944**

R.A. =  $19^h 37^m 56^s$  }  
Decl. =  $+ 4^{\circ} 28'$  }

Noted "duplex" in Weisse. It is not double, although there are several stars in the field. The 7.1m star *nf* has a 25' companion *p*. In the D.M. the Weisse star is (4°)4205, and a 9.3m star, No. 4208, is 26.5*f* and 2.2*n*. The difference in R.A. is now much less.

**OΣ (App) 190.** 7.2 ... 12 ... 8.1

R.A. =  $19^h 39^m 50^s$  }  
Decl. =  $+ 46^{\circ} 57'$  }

A and B

1901.471	299.4	11.82
.509	298.8	11.66
1901.49	299.1	11.74

## A and C

1901.471	316.2	67.51
.509	316.3	67.56
1901.49	316.2	67.53

The faint star was added with the 18½-in. No change.

1878.40	300.2	11.64	1 $\alpha$	$\beta$
1876.66	316.5	67.66	3 $\alpha$	$\beta$

## H N. 113

R.A. = 19° 40' 55"	{
Decl. = +37° 15'	

H has no measures; it is given as Class II, with the above place. There is no double star here, and there is little doubt of his observation belonging to  $\Sigma$  2578, which is in the same vicinity *nf*. In the course of this search I ran on to  $\Sigma$  384, and measured it once; 192.7 : 0.98 (1901.47).

## H 898

R.A. = 19° 41' 55"	{
Decl. = +31° 24'	

Described by H as a faint triple, all 11m,  $225^\circ \pm : 2' \pm$  AB;  $225^\circ \pm : 6' \pm$  AC. Very carefully looked for twice, but nothing of this kind found. There are many faint pairs in the vicinity, but not of the description given.

## Ho 114

R.A. = 19° 41' 59"	{
Decl. = +32° 36'	

A and B. 7.2 . . . 13.5

1901.529	233.7	3.15
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A and C (new). C = 14

1901.529	215.4	9.72
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A and D. D = 8.2

1901.471	200.2	31.36
.509	200.4	31.49
.529	200.7	31.47
1901.50	200.4	31.44

AD is H N. 110 = S 726 =  $\Sigma$  (App) 192. The faint star C has not been seen before. There is no material change in the other stars.

 $\Sigma$  2581 *rej.* 8.0 . . . 9.6

R.A. = 19° 43' 8"	{
Decl. = -11° 42'	

1901.455	282.6	38.00
.473	282.7	38.35
.531	282.2	38.37
1901.48	282.5	38.24

The principal star is P XIX. 1058. The observation in Mitchell belongs to some other pair. The only measure is:

1879.54	281.3	37.88	3 $\alpha$	Cin
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## Jacob. 9.0 . . . 9.1

R.A. = 19° 43' 59"	{
Decl. = -11° 5'	

1901.455	320.0	28.66
.473	319.0	28.60
.531	319.0	29.00
1901.49	319.3	28.75

The components are S.D.(11°)5146 and 5147. The only other measures are:

1845.8	319.7	30.80	Jacob
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Hussey in 1899 found A to be a close and unequal pair (= Hu 77). The seeing was too poor to measure AB. This triple is 12 $p$  51 *Aquilae*.

Ho 275. 51 *Aquilae*. 5 . . . 12.9

R.A. = 19° 44' 11"	{
Decl. = -11° 4'	

1901.531	117.5	20.83
.586	116.2	20.94
1901.56	116.8	20.88

The increase in the distance since the measures of Hough agrees with the proper motion of A, 0.08 in 315.5.

H 603. 19 *Cygni*. 6 . . . 9.8 . . . 11.7

R.A. = 19° 46' 19"	{
Decl. = +38° 25'	

A and B

1901.605	103.7	54.29
1902.433	103.9	54.16
1902.02	103.8	54.22

## B and C

1901.605	12°0	21'60
1902.433	13.7	21.99
1902.02	12.8	21.79

Positions estimated by H; he calls C 18m. The large star has a proper motion of 0".112 in 3".6.

1887.81 102°1 53'92 2*n* Engelhardt

**H 900.** 56 *Aquilae*. 6...11.5

R.A. = 19<sup>h</sup> 47<sup>m</sup> 37<sup>s</sup> }  
Decl. = - 8° 53' }

1901.473	76°9	46'33
.531	77.9	46.55
1901.50	76.4	46.44

No measures in H. Unchanged since my measures in 1880.

**Σ 2593** *rej.* 8.3...9.7...11.0

R.A. = 19<sup>h</sup> 47<sup>m</sup> 37<sup>s</sup> }  
Decl. = + 11° 32' }

## A and B

1901.436	236°2	12'34
.452	235.8	12.53
.529	235.6	12.27
1901.47	235.9	12.38

## B and C (new)

1901.436	301°8	3'85
.452	307.4	3.52
.529	303.7	3.72
1901.47	304.3	3.70

No other measures, except Leipsic A.G., 237°0: 12'12 (1893.54). A is D.M.(11°)4030.

**Wilson.** Cord.D.M.(24°)15677. 9...10.4

R.A. = 19<sup>h</sup> 47<sup>m</sup> 46<sup>s</sup> }  
Decl. = - 24° 10' }

1901.605	116°1	17'17
1902.433	116.5	17.32
1902.02	116.3	17.24

Identified as above. The only measure is:

1885.71 117°6 17'34 1*n* H. C. Wilson

**H III. 105 = Σ 2595** *rej.* 9.4...9.7

R.A. = 19<sup>h</sup> 47<sup>m</sup> 55<sup>s</sup> }  
Decl. = + 19° 59' }

1901.436	215°5	16'38
.589	214.2	16.34
1901.51	214.8	16.36

There is a 10m star 37°0: 24'0. The other measures are:

1783.45	219°6	14'48	1 <i>n</i>	<b>H</b>
1881.39	214.9	16.31	3 <i>n</i>	<i>β</i>

Evidently fixed. A is D.M.(19°)4192.

**OΣ 390.**

R.A. = 19<sup>h</sup> 50<sup>m</sup> 19<sup>s</sup> }  
Decl. = + 29° 53' }

## A and B

1901.531	22°2	9'40
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## A and C

1901.531	175°5	16'15
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Without change.

**H 1458.** 8.8...8.8

R.A. = 19<sup>h</sup> 54<sup>m</sup> 22<sup>s</sup> }  
Decl. = + 10° 51' }

1901.436	132°5	16'52
.452	134.8	16.32
.529	133.3	16.06
1901.47	133.5	16.30

The components are D.M.(10°)4132 and 4133. The only complete measure is:

1875.11 133°7 16'04 2*n* J

**H I. 93.** L 38205. 8.0...8.6

R.A. = 19<sup>h</sup> 55<sup>m</sup> 30<sup>s</sup> }  
Decl. = - 0° 32' }

1900.458	293°0	2'14
1901.433	298.9	2.07
.436	299.7	2.14
.452	294.2	1.97
1901.19	296.4	2.08

The change, if any, is a small increase in the angle. There is a 11.5m star, 2°2: 26'6.

**Σ 2612**

R.A. =  $19^{\text{h}}55^{\text{m}}31^{\text{s}}$  }  
 Decl. =  $+ 6^{\circ}36'$  }

1901.452	53.3	38.97
.471	53.7	38.69
.529	53.6	39.05
1901.48	53.5	38.90

The distance is slowly increasing from proper motion, the angle remaining constant. Σ found  $36.59(1827.67)$ . These stars point to a 3 or 4' pair of 12.5m stars about  $30''$  from B.

**Harvard Zones. 8.6 ... 13.0 ... 11.5**

R.A. =  $19^{\text{h}}57^{\text{m}}6^{\text{s}}$  }  
 Decl. =  $+ 0^{\circ}22'$  }

**A and B**

1900.458	145.2	4.39
1901.433	146.1	4.05
1900.94	145.6	4.22

**A and C**

1900.458	189.7	16.24
1901.433	190.5	16.90
1900.94	190.1	16.57

No other measures. The description in H.Z. is  $\alpha f: 4'' \pm: 8-9 \dots 15$ .

**Σ 2619**

R.A. =  $19^{\text{h}}57^{\text{m}}29^{\text{s}}$  }  
 Decl. =  $+ 47^{\circ}56'$  }

**A and B (Σ 2619)**

1901.320	242.0	4.31
1902.433	244.8	4.10
1901.87	243.4	4.20

**A and C**

1901.318	305.0	17.73
.320	303.8	17.35
1902.433	304.2	17.42
1901.69	304.3	17.50

**C and D**

1901.320	179.5	5.12
1902.433	181.8	5.98
1901.87	180.6	5.55

No change in AB. C and D are not in Σ. C was first noted by H. and D added by 0Σ in 1851. The only measures of CD are:

1879.49	183.8	5.45	1 $\mu$	β
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**H 1470. D.M.(37°)3744. 7.0 ... 9.1**

R.A. =  $19^{\text{h}}59^{\text{m}}19^{\text{s}}$  }  
 Decl. =  $+ 37^{\circ}59'$  }

1901.605	337.2	29.18
1902.449	337.2	28.94
1902.02	337.2	29.06

This is H 605, the Decl. of which is uncertain in H. The companion is D.M.(37°)2743. The colors, red and green, are well marked. There is probably a misprint in the distance by Secchi,  $335^{\circ}2:23.83$  (1856.63) 1 $\mu$ .

**26 Cygni. 6 ... 8.3 ... 12.2**

R.A. =  $19^{\text{h}}57^{\text{m}}58^{\text{s}}$  }  
 Decl. =  $+ 49^{\circ}46'$  }

**A and B**

1898.463	147.4	41.98
.518	147.1	41.87
.520	146.8	42.03
1898.50	147.1	41.96

**B and C**

1898.463	74.7	8.74
.520	75.0	9.30
1898.49	74.8	9.02

**B and D (new). D = 13.7**

1898.463	257.2	10.26
.520	257.9	9.94
1898.49	257.5	10.10

The bright stars make H V. 47 = H VI. 60 = 0Σ (App) 197. C was added with the  $18\frac{1}{2}$ -in. in 1878. So far no sensible change in AB.

**H 2927. 7.5 ... 12 ... 13.2**

R.A. =  $19^{\text{h}}59^{\text{m}}13^{\text{s}}$  }  
 Decl. =  $+ 0^{\circ}7'$  }

**A and B**

1901.433	125.3	24.14
.471	126.2	24.44
.512	123.5	24.43
1901.47	125.0	24.34

**B and C (new)**

1901.433	185.7	4.82
.471	186.2	4.94
.512	184.0	4.77
1901.47	185.3	4.84

No complete measures. H gives  $135^{\circ}0$  (1830).

**OΣ 397 rej. = H V. 105.** 7.3 . . . 8.5

R.A. =  $19^{\text{h}} 59^{\text{m}} 16^{\text{s}}$  }  
Decl. =  $+ 15^{\circ} 33'$  }

1900.647	173.1	37.70
.687	173.4	37.86
1900.66	173.2	37.78

Slow change from proper motion.

**OΣ (App) 198**

R.A. =  $20^{\text{h}} 0^{\text{m}} 17^{\text{s}}$  }  
Decl. =  $+ 7^{\circ} 13'$  }

A and B

1901.531	174.0	37.17
.742	173.9	37.41
1901.63	173.9	37.29

A and C

1901.531	186.2	64.91
.703	186.0	65.27
.742	186.0	65.11
1901.66	186.1	65.10

No other measures of B, which was first noted with the  $18\frac{1}{2}$ -in. No change in AC since the measures of A.

**H 1477.** L 38450. 8.0 . . . 10.6

R.A. =  $20^{\text{h}} 0^{\text{m}} 55^{\text{s}}$  }  
Decl. =  $+ 12^{\circ} 20'$  }

1901.531	271.4	20.16
.720	270.6	19.93
1901.62	271.0	20.04

Only H,  $265^{\circ} 0' : 12' \pm$  (1828).

**H IV. 34.** 9.0 . . . 9.4

R.A. =  $20^{\text{h}} 1^{\text{m}} 26^{\text{s}}$  }  
Decl. =  $- 0^{\circ} 57'$  }

1901.509	197.8	47.48
.512	198.1	47.58
1901.51	197.9	47.53

The correct place is given above. A is D.M. ( $-1^{\circ}$ ) 3896. No other measures. H estimated distance  $30''$ .

**H VI. 27.**  $\theta$  Aquilae. 3 . . . 13.0

R.A. =  $20^{\text{h}} 5^{\text{m}} 7^{\text{s}}$  }  
Decl. =  $- 1^{\circ} 11'$  }

1901.512	260.0	113.95
.586	259.9	113.47
1901.55	260.0	113.71

Herschel's place is that of  $\theta$  Aquilae; but in the original Catalogue (*Phil. Trans.* 1782) it is described "a star north of  $\theta$ ; distance about  $1'$ ," and it is not probable that the star measured above is the right one. Most likely it is the 8m star, L 38760, which is  $2^{\text{m}} 43' f \theta$  and  $4.1\text{s}$ . I have measured the components of this (7.1 . . . 8.5) as follows:

1901.512	80.5	64.09
.586	80.3	64.05
1901.55	80.4	64.07

This star has a proper motion of  $0.262$  in  $203^{\circ} 6'$ .

**H VI. 92.** 8.1 . . . 9.0

R.A. =  $20^{\text{h}} 5^{\text{m}} 9^{\text{s}}$  }  
Decl. =  $- 12^{\circ} 26'$  }

1900.512	265.4	84.96
.515	265.4	85.91
.551	265.3	85.00
1901.589	264.9	85.14
1900.79	265.2	85.25

The components are S.D.( $12^{\circ}$ ) 5663 and 5662. The only measures are:

1783.18	267.9	62.27	1m	H
1879.63	265.8	51.35	1m	Cin

An examination of Cin<sup>s</sup> shows that there is an error of 10 revolutions in reading one head, and that the observed distance was  $85.53$  instead of  $51.35$ .

**S 735 = H V. 136.** 7.5 . . . 7.7

R.A. =  $20^{\text{h}} 5^{\text{m}} 9^{\text{s}}$  }  
Decl. =  $- 0^{\circ} 29'$  }

1901.605	206.3	55.25
.703	206.1	55.48
1901.65	206.2	55.36

Only one measure since 1825, but apparently without change.

**S 740 = OΣ (App) 202.** 7.3 . . . 7.4

R.A. =  $20^{\text{h}} 8^{\text{m}} 18^{\text{s}}$  }  
Decl. =  $+ 6^{\circ} 14'$  }

1901.529	192.8	42.96
.703	193.0	43.36
.720	192.6	43.22
1901.65	192.8	43.18

A comparison with the measures of S and A shows that these stars are relatively fixed. They have a common proper motion of  $0.197$  in  $236^{\circ} 1'$  (Bossert). The components are D.M.( $6^{\circ}$ ) 4480 and 4479.

D.M.(0°)4453. 9.0 . . . 10.5 . . . 10

R.A. = 20° 0' 15"  $\frac{1}{2}$   
Decl. = + 0° 20'  $\frac{1}{2}$ 

A and B

1901.799	256.8	1.70
1902.471	258.9	1.88
1902.13	257.8	1.79

A and C

1901.799	270.6	31.48
1902.471	270.7	31.30
1902.13	270.6	31.39

Noted as double in the Harvard Zones. The only other measures are:

AB	1879.46	259.2	1.72	1 <i>n</i>	Cin
AC	1879.46	276.8	31.17	1 <i>n</i>	Cin

 $\sigma$  Capricorni. Sh 380 =  $\mathbb{H}$  V. 87R.A. = 20<sup>h</sup> 12<sup>m</sup> 28<sup>s</sup>  $\frac{1}{2}$   
Decl. = - 19° 30'  $\frac{1}{2}$ 

1901.605	178.0	55.90
.742	177.5	55.90
1901.67	177.7	55.90

No change since my measures in 1881.

 $\nu$  Capricorni. . . . 11.0R.A. = 20<sup>h</sup> 14<sup>m</sup> 0<sup>s</sup>  $\frac{1}{2}$   
Decl. = - 13° 8'  $\frac{1}{2}$ 

1901.605	210.8	54.14
.742	210.5	53.98
1901.67	210.6	54.06

The only measures are:

1896	28.0	56.33	1 <i>n</i>	Lamont
1877.77	210.1	55.38	1 <i>n</i>	$\beta$

 $\mathbb{H}$  2953. D.M.(8°)4408. 8.7 . . . 10.7R.A. = 20° 15' 16"  $\frac{1}{2}$   
Decl. = + 8° 14'  $\frac{1}{2}$ 

1900.706	260.2	25.19
1901.395	261.7	25.52
1901.05	260.9	25.35

Only observed by  $\mathbb{H}$ , 260.4: 18'  $\pm$  9' . . . 16 (1830);  
'delicate and difficult.'

 $\mathbb{H}$  N. 138. S.D.(17°)5954. 8.0 . . . 8.6R.A. = 20<sup>h</sup> 15<sup>m</sup> 23<sup>s</sup>  $\frac{1}{2}$   
Decl. = - 17° 9'  $\frac{1}{2}$ 

1901.455	331.2	3.07
.742	331.5	3.09
1901.60	331.3	3.08

No measures by  $\mathbb{H}$ . Unchanged since my measures of 1878. The first mention of this pair after  $\mathbb{H}$  is by Peters, who found it in observing an asteroid (A.N. 1635).

 $\mathbb{H}$ . C. Wilson. 9.5 . . . 9.5R.A. = 20<sup>h</sup> 17<sup>m</sup> 33<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 5 12'  $\frac{1}{2}$ 

1901.531	359.8	2.14
.720	360.2	2.05
1901.62	360.0	2.09

Discovered by Wilson. The correct place is given above. It is D.M.(5°)4496. The only measures are:

1893.39	359.7	1.80	3 <i>n</i>	Wilson
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 $\mathbb{S}$  749R.A. = 20<sup>h</sup> 21<sup>m</sup> 14<sup>s</sup>  $\frac{1}{2}$   
Decl. = - 2 30'  $\frac{1}{2}$ 

1901.608	189.8	60.00
.720	189.6	59.57
.742	189.6	59.85
1901.69	189.7	59.81

No change since my measures in 1880, and the measures of  $\mathbb{S}$  agree with the last. Bossert gives the proper motion of A 0.161 in 248"2, and B 0.183 in 244.1. The measures show no relative motion.

 $\beta$  363R.A. = 20<sup>h</sup> 24<sup>m</sup> 28<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 20° 12'  $\frac{1}{2}$ 

A and B

1900.438	64.1	18.70
.703	65.2	18.74
.706	64.5	19.14
1900.61	64.6	18.86

## A and C

1900.438	198°4	44'22
.703	199.0	44.58
1900.62	198.7	44.40

These measures indicate that the change in AB is due to the movement of the 11.5m star B, and not the 7m star A.

## H N. 7. 10.0 ... 10.5 ... 10.3

R.A. =  $20^{\text{h}} 26^{\text{m}} 31^{\text{s}}$  }  
Decl. =  $-26^{\circ} 9'$  }

1901.608	340°7	14'84	AB
.608	226.7	20.04	AC

Given by H Class I-II; "very close triple; vertex f." This is the only object I could find answering the description. The places are practically the same. There is a 13m star  $150^{\circ}0:15'3$  from A.

## Σ 2696

R.A. =  $20^{\text{h}} 27^{\text{m}} 34^{\text{s}}$  }  
Decl. =  $+5^{\circ} 2'$  }

## A and B

1901.742	305°7	0'84
.760	307.3	0.70
1901.75	306.5	0.77

## AB and C

1901.742	348°5	13'73
.760	349.0	13.83
1901.75	348.7	13.78

The 14m star, C, was noted by me with the 18½-in. some twenty years ago. No other measures of it. No material change in AB.

Σ 2697 *rej.* 7.5 ... 9.5

R.A. =  $20^{\text{h}} 28^{\text{m}} 13^{\text{s}}$  }  
Decl. =  $-0^{\circ} 53'$  }

1901.720	1°8	30'25
.760	1.8	30.59
1901.74	1.8	30.42

The only other measure is:

1848.67	1°7	32'10	1 <sup>n</sup>	Mitchell
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## Σ 2708

R.A. =  $20^{\text{h}} 34^{\text{m}} 7^{\text{s}}$  }  
Decl. =  $+38^{\circ} 13'$  }

## A and C

1901.318	330°0	27'73
.320	329.9	27.59
1901.32	330.0	27.66

## A and B

1901.320	20°3	15'39
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The 13.5m star B was added by Hall with the 26-in. The principal star has a proper motion of  $0'242$  in  $138^{\circ}7$ , and it is well known that the change in C since Σ corresponds to this movement. The other companion was measured to see whether that showed the same displacement. From a comparison of my position with that of Hall in 1878 it appears that B is fixed in space like the other.

H IV. 78 = Σ 2712 *rej.* 8 ... 11.9

R.A. =  $20^{\text{h}} 34^{\text{m}} 25^{\text{s}}$  }  
Decl. =  $+62^{\circ} 1'$  }

1901.608	124°3	28'92
.758	124.8	28.72
1901.68	124.5	28.82

The only observation is:

1783.22	49°4	19'53	1 <sup>n</sup>	H
---------	------	-------	----------------	---

There is no star in this place. In the notation then in use this angle corresponds to  $40^{\circ}6m$ . If it is read *sf*, the angle would be  $130^{\circ}6$ . The principal star is D.M.(61°)2039.

W<sup>2</sup> XX. 1168

R.A. =  $20^{\text{h}} 35^{\text{m}} 1^{\text{s}}$  }  
Decl. =  $+37^{\circ} 58'$  }

In Weisse, "duplex; comes ad boream." This star has no companion. The description applies to Σ 2708, which is near by.

## H 2988. D.M.(2°)227. 8.5 ... 9.6

R.A. =  $20^{\text{h}} 35^{\text{m}} 52^{\text{s}}$  }  
Decl. =  $+2^{\circ} 32'$  }

1901.512	138°9	24'65
.529	138.3	24.65
1901.52	138.6	24.65

H says, "large star very red." It did not appear so on this occasion, nor when examined by me in 1876.  $139^{\circ}7:20' \pm$  (1830).

**$\beta$  673**R.A. =  $20^h 36^m 29^s$   $\left\{ \right.$ Decl. =  $+20^\circ 17'$   $\left\{ \right.$ 

A and B

1900.438 297.8 3.51

1901.799 296.6 3.83

1901.11 297.2 3.67

A and C

1900.438 165.3 105.8 Single dist.

1901.799 165.0 105.62

1901.11 165.1 105.71

 **$\alpha$  411. 7.8 . . . 10.9**R.A. =  $20^h 38^m 17^s$   $\left\{ \right.$ Decl. =  $+45^\circ 24'$   $\left\{ \right.$ 

1901.531 314.2 17.03

.608 311.6 16.19

1901.57 312.9 16.61

Rectilinear motion.

**H 2994. 17 *Capricorni*.**R.A. =  $20^h 39^m 12^s$   $\left\{ \right.$ Decl. =  $-21^\circ 57'$   $\left\{ \right.$ 

Herschel gives  $338^\circ 7' 20'' \pm 6''$  . . . 18 (1830); "requires verification." I examined this star several times with the 18 $\frac{1}{2}$ -in. in 1877 under favorable conditions without finding any companion; and on two nights was unsuccessful with the 40-in. It is safe to say the suspected companion has no existence.

**Skinner. 8.8 . . . 8.8**R.A. =  $20^h 39^m 46^s$   $\left\{ \right.$ Decl. =  $-17^\circ 8'$   $\left\{ \right.$ 

1900.515 299.8 3.43

1901.471 297.9 3.66

.531 299.1 3.60

1901.17 298.9 3.56

From a list of doubles furnished me several years ago by Professor Skinner, of the Naval Observatory, noted by him in his meridian work. It has since been catalogued by Innes.

 **$\alpha$  412 *rej.* 7.3 . . . 10.9 . . . 10.9**R.A. =  $20^h 41^m 1^s$   $\left\{ \right.$ Decl. =  $+50^\circ 14'$   $\left\{ \right.$ 

A and B

1901.260 280.3 25.21

.318 281.5 25.32

.320 281.1 25.27

1901.30 281.0 25.27

B and C

1901.260 6.0 4.98

.318 9.3 4.83

.320 7.0 4.83

1901.30 7.4 4.88

At this time there were no measures of these stars published.

 **$\eta$  *Cephei*. 3.5 . . . 11**R.A. =  $20^h 42^m 51^s$   $\left\{ \right.$ Decl. =  $+61^\circ 22'$   $\left\{ \right.$ 

1900.684 38.8 85.18

.744 38.5 85.30

1900.71 38.6 85.24

The only previous measures are :

1879.35 33.8 100.54  $2n$   $\beta$ 

The large star has a proper motion of  $0.816$  in  $6^\circ 7'$ , and the computed place of the companion from this movement and the measures of 1879 is  $39^\circ 1' 85.61$ . The small star is therefore not moving with the other.

**H 1381. 55 *Cygni*. 6 . . . 10.8**R.A. =  $20^h 44^m 50^s$   $\left\{ \right.$ Decl. =  $+45^\circ 40'$   $\left\{ \right.$ 

1901.531 174.0 20.70

.608 173.8 20.74

1901.57 173.9 20.72

Without change.

1875.11 174.0 20.49  $2n$   $\beta$ **H 3004. 10.9 . . . 10.9**R.A. =  $20^h 46^m 15^s$   $\left\{ \right.$ Decl. =  $+62^\circ 5'$   $\left\{ \right.$ 

1901.531 197.7 3.74

.758 197.8 3.88

1901.64 197.7 3.81

This is in the field  $p$  the 8m star, D.M.(61°)2057. The only observations are  $193^\circ 5' 13''$  :  $13 = 13$  (1830).

**O.Arg.N. 21247. 8.7 . . . 8.8**R.A. =  $20^h 48^m 2^s$   $\left\{ \right.$ Decl. =  $+53^\circ 36'$   $\left\{ \right.$ 

1901.531 184.3 9.64

.608 183.5 9.53

1901.57 183.9 9.58

"Duplex" in O.Arg. No other measures. The components are *reddish* : *greenish*. Other companions more distant.

**H 5514**

R.A. =  $20^{\text{h}} 49^{\text{m}} 31^{\text{s}}$  }  
 Decl. =  $- 5^{\circ} 31'$  }

Described by H,  $200^{\circ} \pm 7^{\circ} \pm \text{AB}$ ;  $70^{\circ} \pm 12' \pm \text{AC}$ , all small stars. There is a faint triple of 11m stars near this place, but the angles do not correspond. Glasenapp was unable to find it.

**O $\Sigma$  421** *rej.* 8.0 ... 9.3

R.A. =  $20^{\text{h}} 50^{\text{m}} 47^{\text{s}}$  }  
 Decl. =  $+ 31^{\circ} 43'$  }

1901.531      192.6      36.73

Hussey measures a 12.5 star,  $77^{\circ} 5' : 30' 57''$  (1898.58).

**Howe. L 40496.** 6.8 ... 11

R.A. =  $20^{\text{h}} 51^{\text{m}} 2^{\text{s}}$  }  
 Decl. =  $0^{\circ} 0'$  }

1901.529      71.7      26.30

.531      72.0      26.25

1901.53      71.8      26.27

The other measures are:

1879.50      71.8      26.19      2*n*      Cin<sup>5</sup>

The principal star has a considerable proper motion, but the authorities differ as to the amount; 0.109 in  $204^{\circ} 2'$  (Bossert); 0.075 in  $180^{\circ}$  A.G. The stars seem to be moving together.

**D.M.(0 $^{\circ}$ )4621.** 8.8 ... 12.7 ... 9.0

R.A. =  $20^{\text{h}} 51^{\text{m}} 21^{\text{s}}$  }  
 Decl. =  $+ 0^{\circ} 8'$  }

A and B

1901.529      335.7      11.44

.531      334.1      11.36

1901.53      334.9      11.40

A and C

1901.529      138.6      41.25

.531      138.7      41.38

1901.53      138.6      41.31

In the Harvard Zones, "double, comp. *f*." The only measure is:

1879.50      137.4      41.76      2*n*      Cin<sup>4</sup>

**H 3006.** D.M.(2 $^{\circ}$ )4285. 9.7 ... 9.7

R.A. =  $20^{\text{h}} 54^{\text{m}} 51^{\text{s}}$  }  
 Decl. =  $+ 2^{\circ} 29'$  }

1900.551      292.9      1.73

1901.455      289.8      1.53

.512      293.2      1.72

1901.17      292.0      1.66

The prior observations are:

1830	300. +	0.5	1 <i>n</i>	H
1878.17	291.0	1.81	2 <i>n</i>	$\beta$

**L 40682.** 6 ... 8.8

R.A. =  $20^{\text{h}} 54^{\text{m}} 58^{\text{s}}$  }  
 Decl. =  $+ 18^{\circ} 52'$  }

1901.531      333.3      45.92

.720      333.5      45.49

.739      333.4      45.63

1901.66      333.4      45.68

Both stars in D.M. The only measure is:

1880.63      332.7      44.66      2*n*       $\beta$

**D.M.(0 $^{\circ}$ )4644**

R.A. =  $20^{\text{h}} 56^{\text{m}} 24^{\text{s}}$  }  
 Decl. =  $+ 0^{\circ} 10'$  }

Described in the Harvard Zones, *sp*:  $3^{\circ} \pm : 9 \dots 12$ . There is no companion of any kind, and nothing as described near this place.

**H 1606.** D.M.(53 $^{\circ}$ )2533. 8.8 ... 9.7

R.A. =  $20^{\text{h}} 57^{\text{m}} 5^{\text{s}}$  }  
 Decl. =  $+ 54^{\circ} 4'$  }

1901.531      186.4      18.33

.608      185.6      18.51

.739      185.9      18.34

1901.62      186.0      18.39

H gives  $185^{\circ} 1' : 12 \pm$  (1828). There is a fine nebula in the field.

**H 1608.** 7.4 ... 10.7

R.A. =  $20^{\text{h}} 59^{\text{m}} 9^{\text{s}}$  }  
 Decl. =  $+ 11^{\circ} 58'$  }

1901.509      257.9      19.41

.586      257.3      19.73

1901.54      257.6      19.57

The measures at Cin in 1879 show no change. Many stars in the field.

**H 274.** 10.6 ... 11.0

R.A. =  $21^{\text{h}} 1^{\text{m}} 20^{\text{s}}$  }  
 Decl. =  $+ 11^{\circ} 24'$  }

1901.586      91.1      9.46

.589      91.9      9.52

1901.58      91.5      9.49

Not in D.M., but closely *f* D.M.(11 $^{\circ}$ )4483. H found  $93^{\circ} \pm : 5^{\circ} \pm : 9 \dots 10$  (1820).

**H 3009.**  $\chi$  *Capricorni*. 6...11...12.2

R.A. =  $21^{\text{h}} 1^{\text{m}} 41^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $-21^{\circ} 41'$   $\left. \right\}$

A and B

1900.687	66.0	67.17
.742	66.2	66.82
1900.71	66.1	67.00

B and C

1900.687	89.3	18.17
.742	89.5	18.33
1900.71	89.4	18.25

The proper motion is small, 0.053 in 186.0. There is a 15m star  $110^{\circ}9':39.2$  from A. H gives  $68^{\circ}5':70'' \pm$ ;  $90^{\circ} \pm : 10' \pm$  (1830).

**OΣ 527**

R.A. =  $21^{\text{h}} 2^{\text{m}} 1^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+4^{\circ} 40'$   $\left. \right\}$

1900.551	272.3	0.46
.553	266.7	0.41
1900.55	269.5	0.43

**H 3011.** D.M.(5°)4707. 8.2...14.5

R.A. =  $21^{\text{h}} 2^{\text{m}} 1^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $-5^{\circ} 10'$   $\left. \right\}$

1900.703	232.6	17.08
.706	232.8	17.39
1900.70	232.7	17.23

The principal star has a proper motion of 0.170 in 206.0 (Porter). The only measure is:  $255^{\circ}4':20'' \pm$  (1830). There is a 6.3 pair of 11m stars from A,  $269^{\circ} : 148''$ .

**OΣ 428** *ref.*. 7.9...9.7

R.A. =  $21^{\text{h}} 3^{\text{m}} 1^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+6^{\circ} 10'$   $\left. \right\}$

1901.531	256.5	24.11
.586	256.1	24.21
1901.56	256.3	24.16

Without change.

**Harvard Zones.** 8.9...9.2

R.A. =  $21^{\text{h}} 4^{\text{m}} 0^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+0^{\circ} 49'$   $\left. \right\}$

1901.531	318.7	0.94
.586	315.1	0.79
1901.56	316.9	0.86

Noted as double in the Harvard Zones. This is D.M.(0°)4674. Only measured as follows:

1877.06 318.3 0.72 3m J

**S 779.** L 41086. 7.5...8.5

R.A. =  $21^{\text{h}} 4^{\text{m}} 26^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+38^{\circ} 14'$   $\left. \right\}$

1900.725	10.3	112.77
1901.260	10.5	112.37
1900.99	10.4	112.57

There are two or three faint stars between, and many in the field. The only other measures are:

1824.81 10.8 114.78 2m South

**Σ 2778.** 8.5...10.5

R.A. =  $21^{\text{h}} 9^{\text{m}} 28^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $-1^{\circ} 44'$   $\left. \right\}$

1900.551	273.3	19.63
.553	273.0	19.90
1900.55	273.1	19.76

Σ's distance in 1828 of  $21^{\circ}19'$  seems to be too large.

1865.33 269.9 20.21 5m J  
 1880.72 271.2 19.91 2m β

**H 5516**

R.A. =  $21^{\text{h}} 10^{\text{m}} 0^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+2^{\circ} 29'$   $\left. \right\}$

Described by H, "quadruple; all in a line," the principal star 9m and the others 18m and 20m. This place was carefully swept over, but nothing found which seemed to answer the description.

**A.G.C. 13.**  $\tau$  *Cygni*

R.A. =  $21^{\text{h}} 10^{\text{m}} 0^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+37^{\circ} 32'$   $\left. \right\}$

1897.689	324.6	0.94
1898.345	322.2	0.78
.482	322.1	0.86
1898.17	323.0	0.86

**β 163**

R.A. =  $21^{\text{h}} 12^{\text{m}} 47^{\text{s}}$   $\left\{ \right.$   
 Decl. =  $+11^{\circ} 4'$   $\left. \right\}$

1900.782	9.1	82.41
1901.471	9.5	82.55
.512	9.3	82.35
1901.25	9.3	82.44

I have measured this 10.9m distant star for the purpose of having hereafter an independent value of the proper motion of AB.

**H 5265.** 9.6 . . . 10.1

R.A. =  $21^{\text{h}} 15^{\text{m}} 10^{\text{s}}$  }  
Decl. =  $-22^{\circ} 53'$  }

1901.589	191.9	31.68
.758	193.7	31.56
1901.67	192.8	31.62

The principal star is Cord.D.M.(22°)15347. This pair was put on the list to see if the apparent change in distance was real.

1879.65	191.1	22.85	1n	Cin <sup>b</sup>
1890.57	191.1	32.19	2n	Glaserapp

Evidently without change.

**H 281.** D.M.(16°)4505. 8.7 . . . 9.2

R.A. =  $21^{\text{h}} 15^{\text{m}} 32^{\text{s}}$  }  
Decl. =  $+16^{\circ} 14'$  }

1901.589	333.9	13.97
.729	335.3	14.09
1901.66	334.6	14.03

No change since measures of Leavenworth in 1896 and Cin in 1879. H made the distance 17.52 (1829.57).

**H 3023.**  $\beta$  *Equulei*

R.A. =  $21^{\text{h}} 16^{\text{m}} 56^{\text{s}}$  }  
Decl. =  $+6^{\circ} 18'$  }

A and B			
1901.509	258.3	33.86	
.589	258.9	33.88	
1901.55	258.6	33.87	
C and D			
1901.509	188.1	6.13	
.589	187.6	5.48	
1901.55	187.8	5.80	
A and C			
1901.589	306.0	68.49	
A and E			
1901.589	275.3	93.49	

**S 788.** 7.2 . . . 7.3

R.A. =  $21^{\text{h}} 17^{\text{m}} 31^{\text{s}}$  }  
Decl. =  $-7^{\circ} 6'$  }

1900.473	88.1	44.15
.476	88.0	44.43
1900.47	88.0	44.29

No other measures since 1824.

1824.78    83.5    36.78    2n    South

The components are L 41562 and L 41563. The change in distance is supported by the meridian positions, which give, Lalande 37.25 (1800) and Lamont 39.35 (1850).

**H 5517.** 18 *Aquarii*

R.A. =  $21^{\text{h}} 17^{\text{m}} 37^{\text{s}}$  }  
Decl. =  $-13^{\circ} 23'$  }

H has "a most minute point strongly suspected," and gives  $270^{\circ} : 13'$  (1823). I have looked for this many times in the last twenty years with various apertures, without finding anything of this kind. The 40-in. shows nothing nearer than the distant star measured in 1877.

**Hd 165**

R.A. =  $21^{\text{h}} 19^{\text{m}} 48^{\text{s}}$  }  
Decl. =  $-28^{\circ} 50'$  }

The description in the Harvard Observations is  $137^{\circ} : 10' \pm 8\frac{1}{2}' \dots 11$  (1868.82). There certainly is no such pair in or anywhere near this place. I looked for it in 1876, and again with the 40-in. It may be identical with a Cin pair, having about the same R.A., but  $8^{\circ}$  north of the Hd place. The description agrees:  $142^{\circ} 9' : 8' 22' : 8 \dots 10$  (1879.54).

**H 5271.** 10.6 . . . 11.6

R.A. =  $21^{\text{h}} 20^{\text{m}} 44^{\text{s}}$  }  
Decl. =  $-25^{\circ} 24'$  }

1901.760	43.6	6.27
.799	48.0	6.68
1901.78	45.8	6.47

Herschel gives :

1834.6    40.7    15.4    1n    H

**H 1668.** 8.4 . . . 9.5

R.A. =  $21^{\text{h}} 31^{\text{m}} 56^{\text{s}}$  }  
Decl. =  $+23^{\circ} 8'$  }

1901.414	34.8	8.16
.416	37.0	8.31
.473	36.2	8.23
1901.43	36.0	8.23

H gives  $34^{\circ} 2' : 7' \dots 10 \dots 12$  (1828). Noted as double in A.G.

**H 941.** 4 *Pegasi*. 6...12.0

R.A. = 21<sup>h</sup> 32<sup>m</sup> 31<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 5° 14'  $\frac{1}{2}$

1901.471	337.7	26.31
.509	336.2	26.29
.512	338.3	26.10
1901.50	337.4	26.23

H called the small star 17m. The large star has a proper motion of 0.103 in 84.5 (Boss). The only measures are:

1878.71    344.9    25.95    1*n*     $\beta$

**S 798 = H VI. 103.**  $\epsilon$  *Pegasi*

R.A. = 21<sup>h</sup> 38<sup>m</sup> 17<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 9° 20'  $\frac{1}{2}$

A and B

1901.760	325.0	82.16
.818	324.8	82.00
1901.79	324.9	82.08

A and C

1901.760	320.9	140.88
.818	321.8	141.34
.835	321.1	141.11
1901.80	321.3	141.11

The proper motion of A is very small, 0.016 in 132.9. The following are all the measures:

AB	1782.97	322.7	90.93	1 <i>n</i>	<b>H</b>
	1879.54	325.2	81.36	2 <i>n</i>	$\beta$
AC	1825.18	323.0	138.51	2 <i>n</i>	South
	1874.77	321.6	140.41	3 <i>n</i>	$\beta$

 $\mu$  *Cygni*

R.A. = 21<sup>h</sup> 38<sup>m</sup> 46<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 28° 12'  $\frac{1}{2}$

A and C

1900.647	271.5	40.99
.684	271.2	41.06
1900.66	271.3	41.02

This 12.2*m* star was added by me with the 18 $\frac{1}{2}$ -in. The only measures are:

1878.94    263.2    35.34    3*n*     $\beta$

With this place and the proper motion of A (0.353 in 135.4) the computed position of C at the above date is 272.4 : 41.32. It is therefore evident that C does not belong to the binary system.

**H 285.** 11.5...11.6

R.A. = 21<sup>h</sup> 39<sup>m</sup> 48<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 10° 7'  $\frac{1}{2}$

1901.531	66.2	7.44
.604	68.2	7.85
1901.66	67.2	7.64

H estimated distance 2" to 3". It is near D.M. (10°)4617.

**H N. 74 = H 947.** 7...10.7...11.7

R.A. = 21<sup>h</sup> 45<sup>m</sup> 57<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 19° 16'  $\frac{1}{2}$

A and B

1901.799	94.3	19.78
.818	94.1	20.15
1901.81	94.2	19.96

A and C

1901.799	322.4	24.32
.818	321.7	24.34
1901.81	322.0	24.33

Not measured by either Herschel. The only other measures are my own in 1879, which show no change.

**Sh 336.** 7.5...8.1

R.A. = 21<sup>h</sup> 52<sup>m</sup> 36<sup>s</sup>  $\frac{1}{2}$   
Decl. = + 5° 27'  $\frac{1}{2}$

1901.608	224.8	101.05
.739	224.5	100.68
1901.67	224.6	100.86

The other measures indicate some change in distance.

1823.77	226.0	105.86	1 <i>n</i>	Sh
1881.56	224.9	102.17	3 <i>n</i>	$\beta$

The components are D.M.(5°)4915 and 4913.

**H. C. Wilson**

R.A. = 21<sup>h</sup> 54<sup>m</sup> :  $\frac{1}{2}$   
Decl. = + 4° 20'  $\frac{1}{2}$

The description in Cin<sup>10</sup> is 212°1 : 1'20 : 8...9 (1882.76) 1*n*. There is no such pair in or near this place. All the stars are much smaller than 8*m*. The description is not unlike  $\Sigma$  2856, which is 5*m* $\frac{1}{2}$  and 3*n*.

**Howe.** L 42909. 8...10.8...10.5

R.A. =  $21^{\text{h}} 55^{\text{m}} 0^{\text{s}}$   
Decl. =  $-16^{\circ} 1'$

A and B

1901.605	271.6	9.12
.739	270.9	9.14
1901.67	271.2	9.13

A and C (= H 5524)

1901.605	292.4	102.02
.739	291.9	101.71
1901.67	292.1	101.86

No other measures of AC. AB unchanged.

**H 289=H 5525.** 20 *Pegasi*. 6...11.4

R.A. =  $21^{\text{h}} 55^{\text{m}} 14^{\text{s}}$   
Decl. =  $+12^{\circ} 33'$

1901.799	324.6	52.98
.818	324.3	52.84
1901.81	324.4	52.91

The prior measures are:

1878.95 325.5 51.06  $3n$   $\beta$ 

The proper motion of A is  $0.068$  in  $136^{\circ}9$ , which corresponds to the change in distance shown by the measures.

**O $\Sigma$  (App) 228.** 8.1...8.7

R.A. =  $21^{\text{h}} 55^{\text{m}} 51^{\text{s}}$   
Decl. =  $+4^{\circ} 12'$

1901.512	27.2	75.67
.604	27.4	75.60
1901.56	27.3	75.63

The smaller star not in D.M. The other is D.M. (4 $^{\circ}$ )4788. A has a proper motion of  $0.145$  in  $163^{\circ}2$ , which explains the change.

1875.69 28.0 73.52  $3n$   $\gamma$ 

There is a 12m star from A,  $157^{\circ}9 : 25.66$  (1901.60) 1n.

 **$\pi^1$  Pegasi**

R.A. =  $22^{\text{h}} 3^{\text{m}} 54^{\text{s}}$   
Decl. =  $+32^{\circ} 35'$

A and B. B = 13.5

1900.684	317.6	27.42
.687	316.9	27.04
1900.68	317.2	27.23

A and C. C = 11

1900.684	262.3	71.67
.687	262.3	71.74
1900.68	262.3	71.70

A and D. D = 11.5

1900.684	89.3	187.49	Single dist.
.687	89.3	187.51	" "
1900.68	89.3	187.50	

The only prior measures are mine in 1879. There is an error in the printed angle of AB; it should be  $314^{\circ}4$ .

 **$\Sigma$  2866-H 1734**

R.A. =  $22^{\text{h}} 4^{\text{m}} 13^{\text{s}}$   
Decl. =  $+40^{\circ} 4'$

1901.722	53.3	9.16
.796	53.6	9.18
1901.76	53.4	9.17

No recent measures, but unchanged.

**H 1735.** L 43266. 7.2...8.7...11.2

R.A. =  $22^{\text{h}} 4^{\text{m}} 21^{\text{s}}$   
Decl. =  $+44^{\circ} 15'$

A and B

1901.608	110.1	27.18
.758	110.1	27.07
1901.68	110.1	27.12

B and C

1901.608	164.7	22.78
.758	164.0	22.70
1901.68	164.3	22.74

No other measures. The Decl. in H is  $1^{\circ}$  too large. A and B are D.M.(44 $^{\circ}$ )4059 and 4060.

**H 3094.** 10.7...10.7

R.A. =  $22^{\text{h}} 5^{\text{m}} 9^{\text{s}}$   
Decl. =  $+2^{\circ} 21'$

1900.780	301.6	4.80
1901.531	301.7	5.15
1901.15	301.6	4.97

H gives  $315^{\circ}5 : 3' \pm : 10 \dots 10$  (1890). A little  $p$  this, and about  $2's$  is a similar pair, components equal, and same as the other pair;  $114^{\circ}6 : 3.72$  (1901.15) 2n. H 957,  $310^{\circ} \pm : 2' \pm : 11 \dots 11 +$  (1820) should be  $20'n$  of H 3094, but I could find only the pairs measured, and the last named probably identical with one of the others.

**H 1741.** B.A.C. 7746. 6.2 . . . 9.7

R.A. =  $22^{\text{h}} 6^{\text{m}} 29^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $+50^{\circ} 14'$   $\frac{1}{2}$

1900.684	308.5	25.21
.687	309.8	25.49
1900.68	309.1	25.35

The principal star has a proper motion of  $0.151$  in  $62^{\circ}5$ , which accounts for the change.

1828	328.5	20	1 $n$	H
1876.29	316.8	23.22	1 $n$	J
1900.68	309.6	25.04	2 $n$	Espin

 **$\Sigma$  2875** *rej.* S.D.(8') 5835. 8.8 . . . 11.6

R.A. =  $22^{\text{h}} 7^{\text{m}} 23^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-8^{\circ} 24'$   $\frac{1}{2}$

1901.605	44.1	15.00
.758	45.6	14.62
1901.68	44.8	14.81

No other measures.

**H I. 49**

R.A. =  $22^{\text{h}} 8^{\text{m}} 3^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $+60^{\circ} 10'$   $\frac{1}{2}$

Given by **H** as Class I with angle 4.2 (1783.06). The place is that of a 6.7 $m$  star. I looked for this carefully in 1876, and now with the 40-in., and there is certainly nothing there. There must be a large error in place.

**H 293 =  $\Sigma$  2888** *rej.* 8.7 . . . 11.0

R.A. =  $22^{\text{h}} 11^{\text{m}} 2^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $+12^{\circ} 22'$   $\frac{1}{2}$

1900.742	276.8	18.41
1901.509	276.8	18.80
.512	275.4	18.44
1901.25	276.3	18.55

This is D.M.(12') 4794. The only prior measures are by **H**,  $276.4 : 10^{\circ} \pm : 9 \dots 13$  (1820).

**H 3104.** S.D.(17') 6488. 9.3 . . . 9.5

R.A. =  $22^{\text{h}} 12^{\text{m}} 35^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-47^{\circ} 42'$   $\frac{1}{2}$

1901.760	76.1	10.39
.799	74.8	10.15
1901.78	75.5	10.27

Only **H**,  $83.9 : 8^{\circ} \pm$  (1830).

 **$\Sigma$  2892** *rej.* 8.4 . . . 11.1 . . . 9.2

R.A. =  $22^{\text{h}} 12^{\text{m}} 55^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-11^{\circ} 24'$   $\frac{1}{2}$

A and B

1901.760	59.1	11.86
.799	56.0	11.53
1901.78	57.5	11.69

A and C

1901.760	263.1	35.96
.799	262.6	35.98
1901.78	262.8	35.97

In *Mens. Microm.*, p. xxxiv,  $\Sigma$  gives :

1831.32	50.0	9.0
1831.32	266.0	35.0

**Howe**

R.A. =  $22^{\text{h}} 14^{\text{m}}$   $\frac{1}{2}$   
Decl. =  $+5^{\circ} 3'$   $\frac{1}{2}$

The measure by Howe in  $\text{Cin}^5$  is  $121^{\circ}6 : 1^{\circ}03 : 8.5 \dots 9.0$  (1879.64) 1 $n$ . This pair should be  $8'$  south of the triple 30 *Pegasi*. There is no such pair either in or anywhere near the given place. All the neighboring stars were examined. It is undoubtedly identical with  $\beta$  842, which is about  $10^{\text{m}}p$  and  $3^{\text{m}}n$  of the place given above. The description corresponds exactly.

**D.M.(10') 4731.** 8 . . . 11

R.A. =  $22^{\text{h}} 14^{\text{m}} 25^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $+10^{\circ} 26'$   $\frac{1}{2}$

1901.589	305.1	39.78
.609	305.4	40.12
1901.60	305.2	39.95

**H** observed this star for  $\Sigma$  2998, which is  $2^{\text{m}}f : 310.7 : 35^{\circ} \pm$  (1830). He called the components *orange* : *blue*. A appears yellowish, but no noticeable color in B.

**H 3106.**  $\gamma$  *Aquarii*

R.A. =  $22^{\text{h}} 15^{\text{m}} 27^{\text{s}}$   $\frac{1}{2}$   
Decl. =  $-1^{\circ} 59'$   $\frac{1}{2}$

1901.586	131.2	41.98
.605	132.8	42.35
1901.59	132.0	42.16

The only measures of this 12.2 $m$  star are :

1838.76	125.9	49.46	1 $n$	Lamont
1878.72	129.6	43.87	1 $n$	$\beta$

The principal star has a proper motion of  $0.103$  in  $80^{\circ}5$ .

**O $\Sigma$  (App) 231.** L 43659. 8.2 ... 8.4

R.A. =  $22^h 16^m 37^s$  }  
 Decl. =  $+ 9^\circ 20'$  }

1901.608	110.2	90.79
.739	110.3	90.92
1901.67	110.2	90.85

The only measures are:

1875.74    109.8    91.02    3    J

**H 1756.** 6.7 ... 10.6 ... 13.2

R.A. =  $22^h 16^m 42^s$  }  
 Decl. =  $+ 40^\circ 4'$  }

A and B

1901.722	286.6	21.85
.739	286.4	22.31
1901.73	286.5	22.08

A and C (new)

1901.722	325.8	22.47
.739	325.8	22.39
1901.73	325.8	22.43

H gives for AB  $283^\circ 5' : 15' \pm : 9 \dots 12$  (1828).  
 The magnitude of A in D.M. is 6.5.

**H 3108 = O $\Sigma$  (App) 232.** 8.4 ... 8.4

R.A. =  $22^h 17^m 34^s$  }  
 Decl. =  $+ 3^\circ 14'$  }

1901.799	190.9	67.67
.818	190.9	67.49
1901.81	190.9	67.58

The other measures are:

1875.98    190.4    65.72    4m    J

**W<sup>2</sup> XXII. 382.** 8.8 ... 9.0

R.A. =  $22^h 18^m 31^s$  }  
 Decl. =  $+ 40^\circ 18'$  }

1901.473	52.3	6.59
.722	55.0	6.49
.739	53.6	6.69
1901.64	53.6	6.59

In Weisse "duplex 6". No other measures.

**H 3116.** D.M.(6°)5023. 9.5 ... 12.5

R.A. =  $22^h 21^m 15^s$  }  
 Decl. =  $+ 6^\circ 56'$  }

1901.720	257.7	25.52
1902.471	257.8	25.95
1902.09	257.7	25.73

No measures in H; "estimated from diagram."

**Harvard Zones.** 9.5 ... 9.6

R.A. =  $22^h 22^m 53^s$  }  
 Decl. =  $+ 0^\circ 40'$  }

1901.720	181.5	3.04
.760	182.5	3.22
1901.74	182.0	3.13

Noted in Hd Zones,  $nf: 3' \pm$ . No other measures.  
 It is D.M.(0°)4879.

**Krueger 60**

R.A. =  $22^h 23^m 43^s$  }  
 Decl. =  $+ 57^\circ 3'$  }

A and B

1901.318	133.3	3.25
.320	130.5	3.37
.375	131.4	3.38
.473	130.4	3.42

1901.37	131.4	3.35
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A and C

1901.318	58.8	36.59
.320	58.5	36.26
.375	58.4	36.69
.473	58.8	36.66

1901.37	58.6	36.55
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A and D

1901.318	98.7	66.73
.328	98.4	66.95
.375	98.5	67.57
1901.34	98.5	67.08

A and D.M.(56°)2784

1901.318	144.62	199.31
.320	144.72	199.50
.375	144.63	199.15
.474	144.52	199.65
1901.37	144.62	199.40

It was apparent soon after the first remeasurement of A by Doolittle that these stars belonged to the type of 61 *Cygni*, where the change in the relation of the components is due to their different proper motions. These are small stars, and their movement in space had not been noticed by meridian observers and those interested in stellar motions.

To determine whether or not the third star, measured by me in 1890, has any proper motion of its own, I have connected A with the nearest bright star, D.M.(56°)2784. The positions of A and this star are in the A. G. catalogue, and these give for the relation of the two  $151^\circ 9' : 195^\circ 35' (1873.2)$ . Comparing this with my direct measures, assuming that the distant star is fixed, we have for the proper motion of A

0:903 in 247°2. The present measures of AC and those of 1890 make this value 0:927 in 244°9. The close agreement of these results makes it practically certain that the change is solely due to the movement of A. Taking the mean, 0:915 in 246°0, as the best value for this motion, and my measures of AB in 1890 and 1901, we have for the proper motion of B 0:702 in the direction of 239°0.

**H 5528**

R.A. = 22<sup>h</sup> 31<sup>m</sup> 22<sup>s</sup> }  
Decl. = + 8° 11' }

H gives 90° ± 1½° : 11 ... 12 (1823); "elongated; not fairly divided." The place is exactly that of the 9.1m star, D.M.(8')4902 = W<sup>1</sup> XXII. 631. I looked at this star with the 6-in. in 1876, and with the 18½-in. in 1877 without seeing any indication of duplicity. I could find no pair in or near this place with the 40-in.

**H 5529. κ Aquarii**

R.A. = 22<sup>h</sup> 31<sup>m</sup> 32<sup>s</sup> }  
Decl. = - 4° 51' }

H describes this 290° ± 4½° ± (1827); "an exceedingly minute point strongly suspected." I have looked in vain for this many times in past years. The 40-in. under fine conditions failed to show any companion. The principal star has a proper motion of 0:142 in 219°2.

**ξ Pegasi. ... 12.0**

R.A. = 22<sup>h</sup> 35<sup>m</sup> 38<sup>s</sup> }  
Decl. = + 10° 12' }

1900.515	139.1	63.45
.551	138.9	63.72
1900.53	139.0	63.58

The only measures are:

1879.54    137.8    64.33    1<sup>st</sup>    β

The proper motion is 0:067 in 105°5, and this appears to account for the change in distance.

**H N. 140. L 44382. 6.5 ... 9.1**

R.A. = 22<sup>h</sup> 35<sup>m</sup> 51<sup>s</sup> }  
Decl. = 5° 44' }

1901.589	262.2	75.21
.703	262.4	75.33
1901.64	262.3	75.27

No measures in **H**, but called Class II. The place is given by H as above. There is nothing of Class II in or near this place.

**Σ 2933 rej. D.M.(10')4804. 9.2 ... 10.4**

R.A. = 22<sup>h</sup> 36<sup>m</sup> 49<sup>s</sup> }  
Decl. = + 10° 22' }

1901.586	218.4	4.10
.589	215.3	4.42
1901.58	216.8	4.26

No other measures.

**H 3139. 13 ... 13**

R.A. = 22<sup>h</sup> 38<sup>m</sup> 37<sup>s</sup> }  
Decl. = + 4° 43' }

1900.725	208.5	2.17
.742	221.7	2.80
1900.73	215.1	2.48

Described by H, 142° : 2° ± : 11 = 11 (1830). The pair measured is in the correct place substantially, but description does not agree. In the field is a triangle of 11m stars, the side of which is about 23'. The *f* star of this triangle is 98°3 : 33'1 from A of the double.

**H 301. ξ Pegasi. 5 ... 12.2**

R.A. = 22<sup>h</sup> 40<sup>m</sup> 42<sup>s</sup> }  
Decl. = + 11° 33' }

1897.714	110.5	12.22
1898.492	108.0	12.61
.502	110.3	12.08
1900.515	110.6	12.36
.551	109.1	12.22
.553	109.3	12.43
1899.39	109.6	12.32

H called the small star 18m, and gave the angle 122°8 (1820). There are no other early measures. The large star has a considerable proper motion, 0:541 in 158°9, and the companion is moving with it.

1866.79	117.7	12.17	2 <sup>nd</sup>	α
1879.38	112.6	11.93	4 <sup>th</sup>	β

**OS 480 = H 1809**

R.A. = 22<sup>h</sup> 41<sup>m</sup> 19<sup>s</sup> }  
Decl. = + 57° 27' }

1900.742	117.3	30.76
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Without change. In 1873 I thought the principal star was elongated, but it was round with all powers at the time of the above measure.

**H VI. 97.**  $\tau^1$  Aquarii. . . . 9.5

R.A. =  $22^h 43^m 14^s$  }  
 Decl. =  $-14^\circ 13'$  }

1900.647	294.4	133.33
.666	293.9	132.95
1900.65	294.1	133.14

No measures in the last seventy-five years.

1783.60	288.5	123.61	1 <i>n</i>	H
1825.30	292.4	133.44	2 <i>n</i>	S

The proper motion is very small, 0.059 in  $227^\circ 5$ .

**H 1825.** D.M.(12°)4904. 9.0 . . . 9.3

R.A. =  $22^h 47^m 50^s$  }  
 Decl. =  $+12^\circ 58'$  }

1900.553	223.2	1.77
.666	222.2	1.77
1900.61	222.7	1.77

H gave  $230^\circ \pm 1^\circ \pm 10 \dots 11$  (1828); "very delicate; could not verify it, having mislaid the high power." No other measures. In 1876 I looked up and estimated distance 1.2.

**H 3152.** L 44810

R.A. =  $22^h 48^m 40^s$  }  
 Decl. =  $-10^\circ 1'$  }

Given by H 135.4:  $3' \pm 9 \dots 15$  (1830). "Large star very red. A very difficult object. Measured with 320, which still left a suspicion of illusion, though I have hardly a doubt." I have looked for this several times previously with apertures up to 18½-in., but have never seen any trace of a companion. It was examined on two nights with the 40-in.

**H 974.** D.M.(4°)4921. 8.7 . . . 9.7

R.A. =  $22^h 49^m 20^s$  }  
 Decl. =  $+4^\circ 11'$  }

1901.529	88.5	44.33
.531	88.3	44.27
1901.53	88.4	44.30

H has  $91^\circ 5'; 40' \pm 9 \dots 12$ . A has a proper motion of 0.11 in  $213^\circ 7$  (Boss.).

 **$\Sigma$  2972** *rej.* D.M.(−0°)4451. 9.3 . . . 11.7

R.A. =  $22^h 56^m 34^s$  }  
 Decl. =  $-0^\circ 23'$  }

1901.589	147.4	15.42
.605	148.5	15.56
1901.60	147.9	15.49

Only H, who has  $198^\circ 0'; 12' \pm 9-10 \dots 14$  (1830). The angles do not agree. Two other similar pairs were measured in the immediate vicinity. The first is D.M.(−0°)4445,  $159^\circ 1'; 24' 40'; 8.5 \dots 12.7$  (1901.60) 1*n*; and the other D.M.(−0°)4453,  $172^\circ 7'; 19' 14'; 10.8 \dots 10.9$  (1901.60) 1*n*. The latter star is 9.5m in D.M.

**H 3164.** L 45137. 6.9 . . . 12

R.A. =  $22^h 58^m 52^s$  }  
 Decl. =  $-17^\circ 44'$  }

1901.586	129.5	55.05
.758	130.0	55.11
1901.67	129.7	55.08

Only H,  $136^\circ 5'; 30' \pm$  (1830).

**Christiania A.G. 3744.** 8.8 . . . 9.0

R.A. =  $23^h 6^m 11^s$  }  
 Decl. =  $+65^\circ 15'$  }

1901.318	265.4	14.83
.474	265.0	14.91
1901.40	265.2	14.87

No change since my measures in 1891.

**H 1855.** 10 . . . 10

R.A. =  $23^h 6^m 18^s$  }  
 Decl. =  $+44^\circ 56'$  }

1900.782	111.2	4.44
1901.320	113.0	4.64
1901.05	112.1	4.54

H gives  $296^\circ 7'; 11\frac{1}{2}'; 11 = 11$  (1828). Not in D.M., but the place is correct.

 **$\Sigma$  2993**

R.A. =  $23^h 7^m 47^s$  }  
 Decl. =  $-9^\circ 35'$  }

A and B

1900.515	176.6	25.41
.744	176.9	25.38
1900.63	176.7	25.39

No relative change, but they have a common proper motion of 0.519 in  $93^\circ 4$ . There is a distant star not moving with the others.

1900.515	114.5	126.08
.666	114.5	126.17
.744	114.5	125.85
1900.61	114.5	126.07

1824.82    109.2    158.17    2*n*    South

**$\beta$  182**

R.A. =  $23^{\circ} 10' 52''$   
Decl. =  $-14^{\circ} 28'$

A and B		
1900.742	41.4	0.60
1901.586	43.3	0.56
1901.16	42.3	0.58
AB and C		
1900.606	77.5	69.49
742	77.7	69.56
744	77.2	69.61
1900.72	77.5	69.55
1901.586	77.0	70.03
.608	77.4	70.20
1901.59	77.2	70.11

I measured the distant star first in 1898 in order to get an independent value for the large proper motion given the close pair from meridian observations (1902 in 2012).

1898.66    79.9    68.04     $2\mu$      $\beta$

The measures indicate that this unusually large proper motion for a faint star is substantially correct.

**H 3183. 9.1 ... 12.1 ... 12.1**

R.A. =  $23^{\circ} 11' 43''$   
Decl. =  $-2^{\circ} 23'$

A and B		
1901.605	95.3	95.76
.720	95.9	95.60
1901.66	95.6	95.68
B and C		
1901.605	11.2	4.37
.720	16.3	4.34
1901.66	13.7	4.35

A = S D 2 5921. H gives for BC 12.3 : 2 (1830).

**H VI 61**

R.A. =  $23^{\circ} 11' 14''$   
Decl. =  $-4^{\circ} 44'$

Herschel's place is that of 7 *Piscium*. His description is, "they form a triangle, each side of which is about 1 ..." and quoted as it is from the faint star. I could not find anything here which could be satisfactorily identified.

**H 3185. Neb. ... 13.4**

R.A. =  $23^{\circ} 15' 36''$   
Decl. =  $+8^{\circ} 14'$

1901.720	164.0	21.12
.760	163.3	21.37
1901.74	163.6	21.24

Described by H,  $160^{\circ} \pm : 14 \dots 14$  (1830); "a double with some nebulous appendage." A of the above measures is a faint nebula (Dreyer 7634). No star was seen in the nebula.

**H 1889. 7.7 ... 12 ... 11.7**

R.A. =  $23^{\circ} 26' 4''$   
Decl. =  $+37^{\circ} 39'$

A and B		
1900.706	241.4	44.05
.744	241.1	43.80
1900.72	241.2	43.92
A and C		
1900.706	57.8	55.79
.744	57.1	55.84
1900.72	57.4	55.81

H gives AB  $238^{\circ} 2 : 20^{\circ} \pm$ ; AC,  $58^{\circ} 2 : 25^{\circ} \pm$  (1828). There is a 13.5m star from A  $211^{\circ} 8 : 29^{\circ} 6$ .

**Winnecke. 8.5 ... 9.2**

R.A. =  $23^{\circ} 26' 35''$   
Decl. =  $+30^{\circ} 47'$

1901.796	164.9	1.59
.815	166.0	1.37
1901.80	165.4	1.48

The only measures are:

1833.85    168.5    1.51     $2\mu$     Win

There is a 13.5m star  $133^{\circ} 2 : 23^{\circ} 4$ , and a 3' pair of 10.5m stars in the field *sp*. The principal star has a proper motion of  $0.148$  in  $61^{\circ} 4$  (Kustner). Evidently the components are moving together.

**H N. 35 = H 316. 6.9 ... 10.8**

R.A. =  $23^{\circ} 31' 27''$   
Decl. =  $-13^{\circ} 44'$

1901.608	92.9	33.21
.758	92.7	33.09
.796	92.3	33.37
1901.72	92.6	33.22

The only prior measures:

1877.83    92.7    33.22     $1\mu$      $\beta$

**H 1898.**  $\kappa$  *Andromedae*. 4...11.1...11.1

R.A. =  $23^h 34^m 30^s$  /  
Decl. =  $+43^\circ 40'$  \

A and B

1901.625	191.9	46.82
.815	191.6	46.69
1901.72	191.7	46.75

A and C

1901.625	294.5	105.08
.815	294.8	104.83
1901.72	294.6	104.95

The proper motion of A is  $0.078$  in  $107.8$ , which explains the change in the distance of C.

1879.24	188.7	46.64	3 <i>n</i>	$\beta$
1879.24	294.6	103.17	1 <i>n</i>	$\beta$

**W<sup>1</sup> XXIII. 696**

R.A. =  $23^h 35^m 7^s$  }  
Decl. =  $-5^\circ 5'$  }

"Duplex" in Weisse, but this is an error, as this star is not a double of any class. The wide pair measured for this in Cin<sup>5</sup> is  $1^m 28^p$  and  $5.5n$ . No change in that.

1901.796	67.5	42.02	9.0...9.5	1 <i>n</i>
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 **$\Sigma$  3032 rej.** L 46416. 8.3...10.0

R.A. =  $23^h 35^m 16^s$  }  
Decl. =  $+14^\circ 7'$  }

1901.720	338.9	19.23
.758	339.0	19.23
1901.74	338.9	19.23

The only observations by H, 339.5:  $15' \pm$  (1828).

**Harvard Zones.** 9.7...13.0

R.A. =  $23^h 35^m 50^s$  }  
Decl. =  $+0^\circ 41'$  }

1901.605	146.0	75.64
.608	146.3	75.64
1901.60	146.1	75.64

In Hd Zones *sf*:  $30' \pm$ : 9...14. A is D.M.(0') 5035.

**Egbert.** D.M.(16) 4980. 8.7...8.8

R.A. =  $23^h 40^m 26^s$  /  
Decl. =  $+16^\circ 25'$  \

1901.608	88.2	1.32
.703	85.5	1.22
1901.65	86.8	1.27

Given with approximate place in Cin:

1879.66	89.0	1.37	2 <i>n</i>	Cin
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Also noted as double in A.G.

**J 28.** D.M.(62<sup>2</sup>) 2296. 8.6...10.8...10.1

R.A. =  $23^h 41^m 32^s$  }  
Decl. =  $+62^\circ 33'$  }

A and B

1900.742	357.9	1.73
1901.722	359.2	1.56
1901.23	358.5	1.64

A and C

1900.742	144.7	10.43
1901.722	144.8	10.54
1901.23	144.7	10.48

Discovered by Dembowski in 1876. Only his measures:

1877.29	358.6	1.61	3 <i>n</i>	J
1877.29	143.6	10.33	3 <i>n</i>	J

**S 835.** 20 *Piscium*. 6...8.6

R.A. =  $23^h 41^m 46^s$  }  
Decl. =  $-3^\circ 26'$  }

1900.553	285.0	172.65
.666	285.3	172.81
1900.61	285.1	172.73

The only prior measures are:

1824.83	287.2	170.92	2 <i>n</i>	South
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**W<sup>2</sup> XXIII. 896**

R.A. =  $23^h 43^m 15^s$  }  
Decl. =  $+24^\circ 41'$  }

"Duplex" in Weisse, but certainly not double.

**W<sup>1</sup> XXIII. 865**

R.A. =  $23^{\text{h}} 43^{\text{m}} 40^{\text{s}}$  }  
 Decl. =  $+16^{\circ} 12'$  }

"Duplex" in Weisse. Examined twice, and not a double of any kind.

**H 319.** D.M.(10<sup>3</sup>)5003. 9.5 ... 11.7

R.A. =  $23^{\text{h}} 45^{\text{m}} 42^{\text{s}}$  }  
 Decl. =  $+10^{\circ} 37'$  }

1901.605	285.1	15.49
.608	284.3	15.29
1901.60	284.7	15.39

No other measures.

**W<sup>1</sup> XXIII. 1008.** 9.0 ... 9.1

R.A. =  $23^{\text{h}} 50^{\text{m}} 40^{\text{s}}$  }  
 Decl. =  $+1^{\circ} 11'$  }

1900.780	253.4	11.86
.782	254.0	11.76
1900.78	253.7	11.81

"Duplex" in Weisse. No other measures.

**H 321.** 7.5 ... 11.2

R.A. =  $23^{\text{h}} 51^{\text{m}} 38^{\text{s}}$  }  
 Decl. =  $+10^{\circ} 48'$  }

1901.703	132.9	20.30
.720	132.3	20.64
1901.71	132.6	20.47

No other measures.

D.M.(10<sup>3</sup>)5017. 8 ... 12.5

R.A. =  $23^{\text{h}} 53^{\text{m}} 39^{\text{s}}$  }  
 Decl. =  $+10^{\circ} 35'$  }

1901.608	122.7	25.76
.760	120.7	25.56
1901.68	121.7	25.66

Measured the first time by mistake for the preceding pair, H 321. No other observations.

**Camb. A.G. 14394**

R.A. =  $23^{\text{h}} 54^{\text{m}} 16^{\text{s}}$  }  
 Decl. =  $+26^{\circ} 15'$  }

Noted in Camb. A.G. as a "close double." I have looked at this 6.5m star three times in 1901. On the last occasion 85 *Pegasi*, which is close by, was easily measured. At no time was there any indication of this star being a double of any kind.

**Duner.** D.M.(6<sup>3</sup>)5233. 9.0 ... 9.5

R.A. =  $23^{\text{h}} 55^{\text{m}} 11^{\text{s}}$  }  
 Decl. =  $+7^{\circ} 2'$  }

1900.666	264.8	15.04
.668	263.8	15.11
1900.66	264.3	15.07

The only measures are:

1869.31	265.3	15.26	3a	Duner
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 **$\beta$  733. 85 *Pegasi***

R.A. =  $23^{\text{h}} 55^{\text{m}} 54^{\text{s}}$  }  
 Decl. =  $+26^{\circ} 27'$  }

A and B

1900.854	253.0	0.97
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A and C

1900.854	342.6	36.65
.873	342.1	36.55
1900.86	342.3	36.60

**W<sup>1</sup> XXIII. 1147**

R.A. =  $23^{\text{h}} 54^{\text{m}} 49^{\text{s}}$  }  
 Decl. =  $+2^{\circ} 43'$  }

"Duplex" in Weisse. There is no companion star near enough to be mentioned.

## II. NEW DOUBLE STARS

**$\beta$  1291.** D.M.(37<sup>3</sup>)94. 8.4 ... 12.8

R.A. =  $0^{\text{h}} 28^{\text{m}} 50^{\text{s}}$  }  
 Decl. =  $+37^{\circ} 2'$  }

1900.725	168.7	2.94
.742	169.0	2.75
.780	169.6	2.85
1900.75	169.1	2.78

**$\beta$  1292.** D.M.(3<sup>3</sup>)161. 8.5 ... 9.0

R.A. =  $1^{\text{h}} 1^{\text{m}} 35^{\text{s}}$  }  
 Decl. =  $+3^{\circ} 43'$  }

1900.780	24.5	0.31
1901.586	24.8	0.36
.796	26.4	0.23
1901.39	24.2	0.30

**$\beta$  1293.** L 5287. 7.1 ... 10.7

R.A. =  $2^h 45^m 56^s$  }  
 Decl. =  $+ 46^\circ 40'$  }

1900.687	352.6	1.73
.780	350.9	1.68
.782	352.9	1.75
1900.75	352.1	1.72

Found in measuring  $\Sigma$  324 *rej.*, which is  $2^m 31^s f$  and 0.9s.

 **$\beta$  1294.** D.M.(46°)734. 8.8 ... 8.9

R.A. =  $3^h 12^m 21^s$  }  
 Decl. =  $+ 46^\circ 15'$  }

1901.589	228.9	6.33
.742	226.8	6.26
.758	227.7	6.14
1901.69	227.8	6.24

The components are red and green. The D.M. magnitude of A is 9.2.

 **$\beta$  1295.** 2 *Camelopardali*. 5 ... 7

R.A. =  $4^h 30^m 27^s$  }  
 Decl. =  $+ 53^\circ 14'$  }

A and B

1901.758	139.2	0.15
.796	138.5	0.25
.818	140.7	0.21
.854	143.3	0.24
1901.80	140.4	0.21

AB and C (=  $\Sigma$  566)

1900.780	290.0	1.61
.782	286.5	1.60
1901.589	289.5	1.42
1901.05	288.7	1.54

AB and D

1900.780	212.4	23.13
.782	212.5	23.35
1901.589	213.6	23.30
1901.05	212.8	23.26

The principal star of the  $\Sigma$  pair is a close and somewhat unequal double, and is certainly a binary system, and probably in rapid motion. The  $\Sigma$  companion was measured by me in 1888 with the 36-in., and the close pair would have been detected with the present distance. The large star has a proper motion of 0.100 in 153.2 (Porter), which is also the movement of the old companion. That star is in

slow retrograde motion about the close pair, as will be seen from the following measures:

1829.79	311.4	1.58	4 <i>m</i>	$\Sigma$
1846.44	304.6	1.61	3 <i>m</i>	$\alpha\Sigma$
1870.02	299.0	1.63	3 <i>m</i>	$\perp$
1888.92	291.9	1.58	3 <i>m</i>	$\beta$
1901.05	288.7	1.54	3 <i>m</i>	$\beta$

The small star D was added by me with the 36-in. The only other measures are:

1888.92	209.8	23.66	3 <i>m</i>	$\beta$
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With this position and the proper motion of AB the place of C at the date of my last measures should be  $212^\circ 3' 23.16$  (1901.05). As this is practically identical with the measures, it is certain that the small star does not belong to the triple system.

 **$\beta$  1296.** L 12112. 8.0 ... 8.5

R.A. =  $6^h 14^m 6^s$  }  
 Decl. =  $- 7^\circ 12'$  }

1900.780	201.0	0.21
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A close and difficult pair found in measuring H 2315, which is  $58^s f$  and  $3.2s$ .

 **$\beta$  1297.** S.D.(22°)4158. 8.7 ... 9.5

R.A. =  $16^h 15^m 10^s$  }  
 Decl. =  $- 22^\circ 21'$  }

1901.359	140.6	1.91
.395	137.0	1.92
.433	137.7	1.90
1901.39	138.4	1.91

Found in looking for H 4851.

 **$\beta$  1298.** 7.6 ... 8.9

R.A. =  $16^h 53^m 49^s$  }  
 Decl. =  $+ 9^\circ 52'$  }

A and B

1901.531	91.7	0.26
.586	88.0	...
.589	84.8	0.33
1901.57	88.2	0.29

AB and C (=  $\alpha\Sigma$  App 150)

1901.359	165.4	76.44
.375	164.9	76.62
.586	164.8	76.57
1901.44	165.0	76.54

C and D =  $\Sigma 2111 m$  *mag.* 8.5...12

1901.359	164.0	23.91
.375	164.5	24.19
1901.37	164.2	24.05

The principal star of this wide pair is a close and difficult double. The only other measure of C is:

1874.84 165.2 77.02 3*n* J

Probably no sensible proper motion, as the meridian positions by Lamont give 164.5; 76.74 (1844.5). The close pair has been measured at Mt. Hamilton:

1901.69 92.3 0.26 3*n* Aitken

No other measures of CD.

 **$\beta$  1299.** D.M.(10°)3337. 8.5...8.5...11.5R.A. =  $17^{\text{h}} 51^{\text{m}} 50^{\text{s}}$  *t*  
Decl. =  $+10^{\circ} 58'$  *t*

A and B

1900.476	155.6	0.48
.515	151.6	0.55
1900.49	153.6	0.51

AB and C

1900.476	63.5	26.69
.512	62.7	27.44
.515	62.7	27.13
1900.50	63.0	27.09

The close pair was suspected with the 6-in. in 1872, and subsequently overlooked until the present time.

 **$\beta$  1300.** 30 *Sagittarii*. 6...13R.A. =  $18^{\text{h}} 43^{\text{m}} 38^{\text{s}}$  *t*  
Decl. =  $-22^{\circ} 15'$  *t*

1900.473	247.6	21.28
.512	245.6	21.40
1902.567	246.5	21.71
1901.18	246.6	21.46

The large star has a small proper motion, 0.075 in 260.0.

 **$\beta$  1301.** L 37588. 8.5...9.5...9.5R.A. =  $19^{\text{h}} 40^{\text{m}} 25^{\text{s}}$  *t*  
Decl. =  $-4^{\circ} 0'$  *t*

A and B

1900.551	66.3	56.76
.553	66.7	56.89
.647	67.0	56.74
1900.58	66.7	56.80

B and C

1900.551	336.6	0.66
.553	337.1	...
.742	341.1	0.68
.780	334.1	0.62
1900.66	337.2	0.65

This is 27*t* and 3*n* of  $\beta$  468. **$\beta$  1302.** D.M.(22°)4170. 8.2...12.3...8.4R.A. =  $20^{\text{h}} 39^{\text{m}} 32^{\text{s}}$  *t*  
Decl. =  $+22^{\circ} 45'$  *t*

A and B

1901.414	140.2	2.15
.416	134.7	2.03
.433	142.3	2.21
1901.42	139.1	2.13

A and C

1901.414	209.0	52.31
.416	208.5	52.21
.433	209.2	52.06
1901.42	208.9	52.19

C is D.M.(22°)4169. The A.G. positions give  $208^{\circ} 0' : 51.87$ .

 **$\beta$  1303.** L 41147. 7...13.2R.A. =  $21^{\text{h}} 6^{\text{m}} 56^{\text{s}}$  *t*  
Decl. =  $+2^{\circ} 19'$  *t*

1900.551	235.0	3.91
.553	237.5	4.00
.725	236.9	4.14
1900.61	236.5	4.02

 **$\beta$  1304.** L 41433. 8.1...12.7R.A. =  $21^{\text{h}} 14^{\text{m}} 7^{\text{s}}$  *t*  
Decl. =  $-2^{\circ} 1'$  *t*

1900.473	57.1	3.29
.476	57.8	3.23
.515	60.9	2.82
1900.49	58.6	3.11

Found in looking for  $\Sigma 2778$ . **$\beta$  1305.** D.M.(12°)4622. 8.8...9.9...10.5R.A. =  $21^{\text{h}} 39^{\text{m}} 9^{\text{s}}$  *t*  
Decl. =  $+10^{\circ} 14'$  *t*

B and C

1901.531	50.8	0.97
.760	45.7	0.98
1901.64	48.2	0.97

# CORRECTIONS

Page 5. O.Arg.N.21. For 2°592 read 22°59.

13.  $\Sigma$  353 *rej.* In the angle by H for 56°4 read 65°4.

18. D.M.(21°)694. In the note for 10°n read 10'n.

28. S 550. For L 15459 and 15460 read 14559 and 14560.

35. Howe. The pair measured is new. The Howe pair was afterwards found and identified as D.M.(24°) 2709.

37.  $\Sigma$  2031 *rej.* For D.M.( - 1°)3761 read D.M.( - 1°)3161.

57.  $\theta$  Aquilae. In the proper motion for 203.6 read 336°7.

60. O $\Sigma$  412 *rej.* In the R.A. for 41° read 42°.

74.  $\beta$  1305. For D.M. (12°)4622 read D.M.(10°)4622.



A and BC		
1901.531	90°9	88.46
.605	91.5	88.87
1901.57	91.2	88.66

**β 1306.** D.M.(22°)4484

R.A. =  $21^{\text{h}} 43^{\text{m}} 58^{\text{s}}$  }  
 Decl. =  $+ 23^{\circ} 1'$  }

A and B. 8 . . . 12.3

1901.414	295°7	31'25
.416	294.4	31.64
.433	294.9	31.05
1901.42	295.0	31.31

C and D. 12.2 . . . 12.6

1901.414	346°9	1'01
.433	337.5	0.96
.799	344.8	1.68
1901.55	343.1	1.22

A and CD

1901.414	275°9	33'03
.416	275.6	32.88
.433	276.2	32.84
1901.42	275.9	32.92

**β 1307.** 53 *Aquarii*

R.A. =  $22^{\text{h}} 20^{\text{m}} 3^{\text{s}}$  }  
 Decl. =  $- 17^{\circ} 21'$  }

A and B (= H N. 41 = Sh 345)

1900.687	309°3	6'99
.742	309.7	6.87
.780	309.2	6.92
1900.73	309.4	6.93

B and C

1900.742	339°5	46'49
.780	338.6	46.62
1901.758	339.1	46.86
1901.09	339.1	46.66

C and D (new). 12.9 . . . 13.9

1900.742	95°7	2'12
.780	101.4	1.75
1901.758	102.4	1.59
.854	106.2	1.85
1901.28	101.4	1.83

In measuring the faint star C as a check hereafter on the proper motion of AB as given from meridian positions, it was found to be a rather difficult pair. C has not been measured before. Porter gives the movement:

A	0'203 in $90^{\circ}0$
B	0.212 in $84.3$

He says that the value for the preceding star (Bradley 2953) is somewhat uncertain, and it is evident that if the direction of the motion of A is correct, the direction of B must be more than  $90^{\circ}$ , since the stars are approaching each other. Comparing the measures of AB given above with those of Dembowski in 1866, with Porter's proper motion of A, we have  $0'244$  in the direction of  $91^{\circ}7$  for the movement of B. The nearest approach of the components will occur in about 145 years, when the distance between them will be only  $2''$ . This system is like that of 61 *Cygni*, and a large number of similar pairs where the respective components have nearly the same movement in space.

**β 1308.** D.M.(12°)4837. 9.4 . . . 12.2 . . . 13.3

R.A. =  $22^{\text{h}} 26^{\text{m}} 18^{\text{s}}$  }  
 Decl. =  $+ 12^{\circ} 34'$  }

B and C

1900.782	56°5	1'20
.796	62.2	0.78
.854	71.9	1.32
1901.81	63.5	1.10

A and B (= H 1776)

1900.744	274°7	9'06
.782	273.7	9.44
1901.720	273.8	9.52
1901.08	274.1	9.34

The close pair is a difficult object. H gives for AB  $277^{\circ}5 : 5'' \pm$  (1828).



# MICROMETRICAL OBSERVATIONS OF EROS



# MICROMETRICAL OBSERVATIONS OF EROS MADE WITH THE FORTY-INCH REFRACTOR OF THE YERKES OBSERVATORY DURING THE OPPOSITION OF 1900-1901

E. E. BARNARD

IN accordance with the scheme for a systematic series of observations of *Eros*, carried on in this country and in Europe, for a redetermination of the solar parallax, the following observations of the planet have been made with the filar micrometer of the forty-inch telescope.

A few explanations only are necessary for a proper understanding of the measures. The times of observation are referred to the 90° meridian and are 6<sup>h</sup> 0<sup>m</sup> 0<sup>s</sup> slow of Greenwich mean time. The last two columns contain the parallax factors in time and arc.

In the first column for  $\Delta a$  the uncorrected value is given; following this is the correction for refraction. The next column contains the value of the  $\Delta a$  corrected for refraction. The  $\Delta \delta$  is treated in a similar manner. In the column immediately following the times is given the number of the comparison star. The magnitudes of these stars are sometimes indicated in this column; but an extra list gives the magnitudes of all the comparison stars. In the next column are the number of independent settings which go to make up the observation — they are generally five in number.

The corrected  $\Delta a$  are yet to be multiplied by  $\frac{1}{18}$  sec  $\delta$ . From the uncertainty of the positions of the comparison stars at present, it has not been thought desirable to reduce these  $\Delta a$  to time.

No correction has been applied to the micrometer screw for temperature, because both screw and tube are of steel, and hence have the same temperature coefficients which, acting in different directions, mutually cancel each other. A shortening or lengthening of the screw by cold or heat is compensated by a corresponding shortening or lengthening of the tube. Observations of *Atlas* and *Pleione* of the *Pleiades*, carried through some five years, have shown that the change of the focal length of the great glass alone is to be taken into account, and only a small portion of this — the difference between the change in the tube and the change in the focus. From summer to winter the focus shortens from the action of the cold upon the lens. The shortening of the focus is greater than that of the tube, the extreme difference being about 0.3 inch, though the entire shortening of the focus is upward of three-fourths of an inch. This difference is the only temperature change that will affect the measures, and is easily taken into account by the following small table, which shows the effect of this difference between change of focus and tube for a measured distance of 300":

CORRECTIONS FOR FOCUS SCALE READINGS

Change in Scale (inch)		Correction
0.01	—	0.003
0.05	—	0.016
0.10	—	0.033
0.15	—	0.049
0.20	—	0.066
0.25	—	0.082
0.30	—	0.098
0.35	—	0.114

If the scale reading for focus has not been read, this table can be used in conjunction with the following table, which depends on the temperature, and which has been deduced from the measures of *Atlas* and *Pleione* referred to:

Temperature	Scale Reading	Temperature	Scale Reading
- 80 (F.)	2.305 inches	+ 25° (F.)	2.132 inches
- 75	2.290	+ 20	2.116
+ 70	2.274	+ 15	2.101
+ 65	2.259	+ 10	2.085
+ 60	2.244	+ 5	2.069
+ 55	2.227	0	2.054
- 50	2.212	- 5	2.039
- 45	2.195	- 10	2.022
+ 40	2.180	- 15	2.006
+ 35	2.163	- 20	1.991
+ 30	2.148	- 25	1.975

It is not recommended that this table be used for these observations of *Eros*, for reasons that will be given in a paper on the focal changes of the great telescope, to be published later.

The extreme change from the setting, 2.20 inches, to which the value of the micrometer screw has been adjusted, and which occurs at a temperature of 50° F., would scarcely exceed 0.10 inch throughout the observations of *Eros*, and would introduce an error of only something like 0.003 in the largest distance measured.

The value of one revolution of the micrometer screw used in these observations was determined from many measures of the difference of declination of *Atlas* and *Pleione*, *Electra* and *Celaeno*,  $\theta'$  and  $\theta''$  *Tauri*, etc. This value is 9.6665 and was, as stated, determined for a temperature of 50° F. and a scale reading of 2.20 inches. Should it be thought desirable to correct any of these measures for focal change, it can easily be done from the material here given. So far no correction of this kind has been applied.

The micrometer, made by Warner and Swasey, is illuminated by a small electric lamp, the light from which (Burnham's method) is under instant control, so that the wires can be quickly made faint or bright at will. The current is turned off from this, except when the actual measures are made, so that no heating of the screw will occur. The measures were mainly made with a magnifying power of 450 diameters, but a power of 700 was frequently used when the distances were not too great and the atmosphere steady enough. In all the measures, to avoid parallax, the objects have been bisected in the center of the field by a quick adjustment of the eyepiece over the object.

The parallel to the equator was carefully determined at the point of observation. With this setting, the  $\Delta\delta$  was measured; the wires were then revolved 90° in position angle and a set of  $\Delta\delta$  obtained by direct measures. The micrometer was then revolved back through 90° and another set of  $\Delta\delta$  secured. In the absence of a chronometer a good Howard watch was used for recording the observations. Its error was determined by comparison with the standard Howard clock of the Observatory. The time of each setting was recorded to the nearest second by the observer himself, who worked without any recorder.

The distances measured were limited to about 5' by the construction of the micrometer. Knowing the desirability of securing measures with as many comparison stars as possible, the planet was connected with every star directly available and not too faint. In making the measures it was thought best to finish, say, the settings for  $\Delta\alpha$  for each of the stars in turn before revolving the wires for the  $\Delta\delta$ . This was done as quickly as possible with due reference to accuracy. The  $\Delta\delta$  was then measured for all the stars, and the micrometer turned back again for the  $\Delta\alpha$ . Though, by this method, the observations were not strictly symmetrical in some cases, it is thought that the additional advantage of so many comparison stars observed at the same time will more than balance this. The parallel was carefully determined several times each night, both at the point of observation and at the equator near the meridian.

The collimation of the micrometer threads remained constant with scarcely any perceptible

change throughout the observations. The wires of the micrometer were frequently examined, to see that they were parallel to each other, and in the measures they were frequently interchanged, thus to a certain extent producing the effect of double distances.

It was necessary frequently to use very small comparison stars, because no others were within reach of the micrometer. After *Eros* passed from the Milky Way, the presence of considerable stars in the field became quite rare. Early notification of this fact was sent to Paris, and it is assumed that the photographic plates will contain the comparison stars down to at least the  $12\frac{1}{2}$  magnitude. In some cases it was necessary to use 13m stars.

The corrections for refraction have been computed by Mr. H. A. Fischer, Jr. (who has also checked the reductions of the observations) from the formulæ

$$\Delta(a' - a) = s \lambda [\tan^2 \zeta \cos(p - q) \sin q + \sec u \sin(p - u)] , \quad (1)$$

$$\Delta(\delta' - \delta) = s \lambda [\tan^2 \zeta \cos(p - q) \cos q + \sec u \cos(p - u)] , \quad (2)$$

which are from Chauvenet's *Spherical and Practical Astronomy*. The original form of the first formula is multiplied by  $\sec \delta$ . This was omitted in the reductions to make the refraction correction in right ascension harmonious with the direct measures of  $\Delta a$ .

The refraction corrections were computed for a mean condition of the barometer without regard to the altitude of the Observatory (about 1,100 feet). The computations were then gone over, and where the error would amount to as much as 0'.01 a special refraction was computed.

Besides the computation of the refractions, Mr. Fischer has done much of the work of compilation, and has otherwise given the most efficient aid in all the work. His skill has aided in the detection and elimination of many errors in the reductions.

A list of barometer and thermometer readings is given farther on. The barometer is located on the wall of the hall at the east end of the main building, some three hundred feet from the large telescope. During the winter this part of the building is heated by steam to a temperature of  $70^\circ$  or  $75^\circ$ , which will account for the relatively high readings of the attached thermometer.

The barometer and thermometer are read by one of the night employees of the Observatory at 9 P. M., 1 A. M., and 4 A. M. No record of the barometer reading is kept by the observer, because of the above three readings each night. The observer, however, always keeps a record at frequent intervals during the night of the thermometers inside and outside the dome.

In nearly all the observations the seeing was poor, and at times very bad. It is not believed, however, that this will materially affect the results, as every precaution was taken to eliminate its effects. In general it meant that a longer time must be devoted to an observation. The major portion of the measures fall in the worst possible season here for observation.

The work was much interfered with by clouds. Every available chance was taken advantage of by the observer to secure frequent measures of the planet during the night, on account of the request that as many observations as possible should be obtained each night to eliminate the effects of clouds at other points. When this was known, the observer began at once to devote as much time as possible throughout the night to observations of the planet.

Altogether there are 1,506 sets of measures, each depending on an average of five settings of the wires; making in all about 7,500 individual settings of the micrometer wires. Each night a diagram of the field of view was made to insure identification of the comparison stars. Copies of all these have been sent to Paris. All of the observations have also been sent to Paris in manuscript.

During the winter of 1901-2 the position of the great telescope was carefully determined from numerous stars, with the following results:

North end of polar axis too low,  $0' 39''$

North end of polar axis too far west,  $0' 45''$

In the winter of 1897 the position was found to be:

North end of polar axis too low,  $0' 10''$

North end of polar axis too far west,  $1' 0''$

showing that the instrument has not materially changed its position in the past four or five years. The horizontal flexure of the tube has not yet been fully determined, though a number of observations have been made for this purpose. The results so far show it must be small. From this it will be seen that the position of the instrument itself can in no way seriously enter into the results as a sensible factor in the differential measures.

The following discordant observations have been noted:

1900, October 14: The observation at  $17^h 10^m$  may be of a fixed star.

1900, October 17: The  $\Delta\alpha$  at  $11^h 49^m 11^s$  does not seem to be reconcilable with the comparison star. Possibly another star was used in this measure.

1900, October 26:  $17^h 36^m 14^s$ . Observation uncertain, on account of clouds.

1900, November 1: This measure is not understood. Question if right comparison star; also question if  $\Delta\alpha$  or  $\Delta\delta$ .

1900, November 3: This is not *Eros*.

1900, November 4: The observation at  $18^h 6^m 51^s$  may be of \* 2 and an 11m star, instead of with *Eros*—there was such a star  $1 = np$ . Same date,  $17^h 57^m 37^s$ . This observation may be uncertain. It does not reconcile closely with the others.

1900, November 26:  $15^h 21^m 43^s$  and  $16^h 10^m 16^s$ . One of these measures seems to be wrong. The last one is perhaps correct.

1900, December 2:  $5^h 42^m 29^s$ . The  $\Delta\delta$  alone was observed for this star.

1900, December 20: These measures made by glimpses through clouds and are an hour apart. It is questioned if they both refer to same star. A break in the clouds each time gave only a few moments' observation.

On January 16 the observation times are subject to some uncertainty. A half-hour after the last observation of *Eros*, while measuring the satellite of Neptune, the watch ran down from want of winding. No comparison had yet been made with the standard clock on that night. The watch had been keeping excellent time previous to this, and also after this date. It is believed the given times can be relied on to within  $5^s$  or less for this date. The night afterward the watch was intentionally allowed to go without winding, and when almost run down its rate did not materially change, so that it is believed the observation times are closely correct; but, of course, there must be some uncertainty attached to them.

The following errors of the watch will, it is thought, give confidence in the close exactness of the observation times:

#### ERRORS OF THE WATCH, 1901, JANUARY

8 <sup>h</sup> 8 <sup>m</sup> 30 <sup>s</sup>	-	-	-	-	fast 0 <sup>m</sup> 43 <sup>s</sup>	16 <sup>h</sup> 9 <sup>m</sup> 5 <sup>m</sup>	-	-	-	-	fast 1 <sup>m</sup> 21 <sup>s</sup>
12 7 21	-	-	-	-	" 0 46	16 10 39	-	-	-	-	" 1 21
14 2 0	-	-	-	-	" 0 44	16 18 23	-	-	-	-	" 1 21
14 9 3	-	-	-	-	" 0 44 $\frac{1}{2}$						
14 11 11	-	-	-	-	" 0 43 $\frac{1}{2}$	17 6 4	-	-	-	-	" 1 19
14 17 23	-	-	-	-	" 0 42	17 7 32	-	-	-	-	" 1 19
16 7 40	-	-	-	-	watch ran down	17 8 59	-	-	-	-	" 1 18 $\frac{1}{2}$
16 8 6	-	-	-	-	fast 1 <sup>m</sup> 20 $\frac{1}{2}$ <sup>s</sup>	17 11 6	-	-	-	-	" 1 19

MICROMETRICAL OBSERVATIONS OF *EROS*

Date 1900 90° Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Oct. 2	8 <sup>h</sup> 12 <sup>m</sup> 5 <sup>s</sup>	1	4	.....	.....	-0' 16.73	+0.03	-0' 16.70	..... +3.79
	8 16 19	2	4	.....	.....	+1 15.53	+0.03	+1 15.56	..... +3.71
	8 21 11	1	4	-0' 51.05	-0.03	-0' 51.08	.....	.....	-06.13
	8 25 35	2	4	+0 5.70	+0.01	+0 5.71	.....	.....	-0.612
	8 33 33	1	5	.....	.....	+0 4.36	+0.03	+0 4.39	+3.26
	8 38 25	2	5	.....	.....	+1 36.99	+0.04	+1 37.03	+3.26
	8 50 8	5	5	.....	.....	-2 37.94	-0.05	-2 37.90	+3.03
	8 56 51	8.6	5	-0 9.49	+0.03	0 9.46	.....	.....	-0.594
	9 3 22	8.6	5	.....	.....	-2 25.31	-0.05	-2 25.36	+2.76
	11 32 21	8.6	5	.....	.....	-0 2.95	0.00	-0 2.95	+0.37
	11 35 22	8.6	5	.....	.....	0 0.00	0.00	0 0.00	+0.34
	11 39 0	8.6	5	-0 11.12	0.00	-0 11.12	.....	.....	-0.341
	11 45 9	8.6	6	.....	.....	+0 9.01	0.00	+0 9.01	+0.21
	11 52 33	8.6	6	-0 11.43	0.00	-0 11.43	.....	.....	-0.311
	16 46 38	12	5	+1 13.19	+0.03	+1 13.22	.....	.....	+0.425
	16 56 4	12	5	.....	.....	+0 15.25	+0.02	+0 15.27	+0.93
	17 4 18	12	5	+1 12.55	+0.02	+1 12.57	.....	.....	+0.458
Oct. 3	12 50 19	1	4	.....	.....	+0 23.66	+0.01	+0 23.67	..... -0.37
	12 55 13	2	4	.....	.....	-0 35.76	-0.01	-0 35.77	..... -0.39
	13 1 7	1	4	+0 2.62	0.00	+0 2.62	.....	.....	-0.130
	13 5 43	2	4	+0 15.63	0.00	+0 15.63	.....	.....	-0.119
	13 11 0	1	4	.....	.....	+0 53.91	+0.01	+0 53.92	-0.46
	13 18 7	2	5	.....	.....	-0 14.46	0.00	-0 14.46	-0.49
Oct. 4	11 59 3	10.3	5	.....	.....	-0 28.05	-0.01	-0 28.06	..... -0.07
	12 6 50	10.3	5	+0 23.61	+0.01	+0 23.62	.....	.....	-0.255
	12 13 6	10.3	5	.....	.....	-0 14.38	0.00	-0 14.38	..... -0.19
Oct. 8	7 27 23	1	5	.....	.....	-0 14.29	+0.06	-0 14.23	..... +4.02
	7 32 50	2	5	.....	.....	-0 21.80	-0.04	-0 21.84	..... +3.91
	7 41 23	1	6	-1 2.71	-0.06	-1 2.77	.....	.....	-0.639
	7 47 33	2	6	+0 32.97	+0.03	+0 33.00	.....	.....	-0.638
	7 54 13	1	5	.....	.....	+0 10.48	+0.05	+0 10.53	+3.45
	7 59 11	2	5	.....	.....	+0 2.64	-0.02	+0 2.62	+3.35
	8 5 37	1	6	-1 6.41	-0.05	-1 6.46	.....	.....	-0.632
	8 11 34	2	6	+0 29.76	+0.02	+0 29.78	.....	.....	-0.630
	8 32 56	B.D.	1	.....	.....	-4 32.01	-0.04	-4 32.05	+2.68
	12 36 25	B.D.	4	.....	.....	-0 51.22	0.00	-0 51.22	-0.06
	12 42 57	B.D.	5	-2 31.64	-0.05	-2 31.69	.....	.....	-0.125
	13 4 28	B.D.	6	.....	.....	-0 26.21	-0.01	-0 26.22	-0.75
	13 10 38	B.D.	4	-2 37.24	-0.05	-2 37.29	.....	.....	-0.047
	16 41 36	1	4	.....	.....	-0 7.05	-0.02	-0 7.07	+0.84
	16 45 42	2	4	.....	.....	-0 5.17	+0.01	-0 5.16	+0.91
	16 50 40	1	4	-1 12.34	-0.03	-1 12.37	.....	.....	+0.497
	16 54 29	2	4	+0 44.84	+0.02	+0 44.86	.....	.....	+0.504
	17 1 48	1	4	-1 14.49	-0.04	-1 14.53	.....	.....	+0.516
	17 5 8	2	4	+0 42.94	+0.02	+0 42.96	.....	.....	+0.522
	17 9 44	9.8	5	-0 59.63	0.00	-0 59.63	.....	.....	+0.529
	17 15 4	9.8	5	.....	.....	-1 56.49	-0.05	-1 56.54	+1.43
	17 20 49	9.8	5	.....	.....	-1 51.43	-0.05	-1 51.48	+1.50
	17 26 37	9.8	5	-1 2.65	-0.01	-1 2.66	.....	.....	+0.555
	17 31 37	9.8	5	-1 3.55	-0.01	-1 3.56	.....	.....	+0.562
	17 36 51	9.8	5	.....	.....	-1 37.93	-0.05	-1 37.98	+1.79
Oct. 9	7 15 30	1	6	.....	.....	+0 1.56	-0.04	+0 1.52	..... +4.15
	7 22 49	2	5	.....	.....	-0 33.84	+0.02	-0 33.82	..... +4.00
	7 30 29	1	6	+0 45.03	+0.04	+0 45.07	.....	.....	-0.646
	7 35 33	2	6	-0 44.34	-0.04	-0 44.38	.....	.....	-0.646
	7 42 33	1	6	.....	.....	+0 26.21	-0.02	+0 26.19	+3.58
	7 47 57	2	6	.....	.....	-0 10.72	+0.03	-0 10.69	+3.48
	7 53 35	1	6	+0 41.01	+0.04	+0 41.05	.....	.....	-0.641
	8 0 7	2	7	-0 48.70	-0.04	-0 48.74	.....	.....	-0.639
	8 32 20	1	5	.....	.....	+1 11.76	+0.01	+1 11.77	+2.55
	8 36 39	3	5	.....	.....	-0 51.43	-0.02	-0 51.45	+2.47
	8 42 24	3	5	+0 2.79	-0.01	+0 2.78	.....	.....	-0.610
	8 47 39	1	5	+0 31.82	+0.03	+0 31.85	.....	.....	-0.605
	14 11 12	9	6	.....	.....	-0 1.66	0.00	-0 1.66	-0.76
	14 15 53	9	4	.....	.....	+0 2.59	0.00	+0 2.59	-0.74
	14 20 42	9	5	-1 20.76	-0.02	-1 20.78	.....	.....	+0.159
	14 26 53	9	5	.....	.....	+0 12.05	0.00	+0 12.05	..... -0.68

## MICROMETRICAL OBSERVATIONS OF EROS

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date & Time	Col. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	$\Delta\delta$
Oct.9	14 32 39	9	-1' 23.04	-0.03	-1' 23.07	.....	.....	.....	+0.192	.....
	16 19 44	1	.....	.....	.....	-0 31.33	0.00	+0 31.33	.....	+0.51
	16 26 20	1	0 33.90	-0.02	-0 33.92	.....	.....	.....	+0.465	.....
	16 32 0	1	.....	.....	.....	+0 41.58	0.00	+0 41.58	.....	+0.68
	16 38 54	1	-0 36.61	-0.02	-0 36.63	.....	.....	.....	+0.488	.....
	16 54 25	2	+0 25.45	+0.03	+0 25.48	.....	.....	.....	+0.516	.....
	17 2 39	2	.....	.....	.....	-1 44.16	0.03	-1 44.19	.....	+1.20
	17 13 56	1	.....	.....	.....	+1 16.98	+0.01	+1 16.99	.....	+1.39
	17 18 46	2	.....	.....	.....	-1 30.45	-0.02	-1 30.47	.....	+1.48
	17 23 49	2	+0 19.39	+0.03	+0 19.42	.....	.....	.....	+0.561	.....
	17 27 55	1	-0 46.82	-0.04	-0 46.86	.....	.....	.....	+0.567	.....
	17 32 15	2	+0 17.37	+0.03	+0 17.40	.....	.....	.....	+0.574	.....
	17 35 58	1	-0 48.49	-0.04	-0 48.53	.....	.....	.....	+0.578	.....
	17 41 0	2	.....	.....	.....	-1 12.04	-0.02	-1 12.06	.....	+1.87
Oct.10	12 49 59	12.7	.....	.....	.....	+0 45.58	+0.01	+0 45.59	.....	-0.87
	12 55 42	12.7	+2 19.73	+0.04	+2 19.77	.....	.....	.....	-0.062	.....
	13 2 29	12.7	.....	.....	.....	+0 56.01	+0.01	+0 56.02	.....	-0.90
Oct.11	6 44 16	1	.....	.....	.....	+0 6.23	-0.17	+0 6.06	.....	+4.58
	6 49 24	1	+2 45.61	+0.17	+2 45.78	.....	.....	.....	-0.649	.....
	7 1 10	2	-1 58.67	-0.11	-1 58.78	.....	.....	.....	-0.652	.....
	7 5 44	4	.....	.....	.....	-0 50.49	+0.08	-0 50.41	.....	+4.13
	7 9 36	2	.....	.....	.....	-0 46.89	+0.08	-0 46.81	.....	+4.05
	7 25 48	1	+2 37.75	+0.13	+2 37.88	.....	.....	.....	-0.653	.....
	7 30 8	2	-2 4.92	-0.10	-2 5.02	.....	.....	.....	-0.652	.....
	7 34 56	2	.....	.....	.....	-0 24.62	+0.08	-0 24.54	.....	+3.52
	7 38 41	1	.....	.....	.....	+0 54.55	-0.08	+0 54.47	.....	+3.44
	7 50 11	1	+2 32.43	+0.12	+2 32.55	.....	.....	.....	-0.646	.....
	7 54 50	2	-2 10.56	-0.10	-2 10.66	.....	.....	.....	-0.645	.....
	8 0 57	1	.....	.....	.....	+1 14.38	-0.06	+1 14.32	.....	+2.97
	8 4 51	2	.....	.....	.....	-0 2.46	+0.08	-0 2.54	.....	+2.89
	13 47 57	1	.....	.....	.....	-0 25.31	0.00	-0 25.31	.....	-0.90
	13 53 3	2	.....	.....	.....	+1 10.24	+0.02	+1 10.26	.....	-0.88
	13 59 1	1	+0 46.69	+0.01	+0 46.70	.....	.....	.....	+0.125	.....
	14 7 18	2	-1 30.76	-0.03	-1 30.79	.....	.....	.....	+0.150	.....
	16 32 10	1	.....	.....	.....	-1 55.56	-0.02	-1 55.58	.....	+0.77
	16 35 31	2	.....	.....	.....	+1 53.16	+0.03	+1 53.19	.....	+0.82
	16 40 55	1	+0 28.89	+0.03	+0 28.92	.....	.....	.....	+0.513	.....
	16 46 5	2	+0 0.66	-0.02	+0 0.64	.....	.....	.....	+0.522	.....
	16 51 48	1	.....	.....	.....	-1 39.65	-0.02	-1 39.67	.....	+1.10
	16 55 51	2	.....	.....	.....	+2 9.73	+0.04	+2 9.77	.....	+1.16
	17 4 45	1	+0 22.72	+0.03	+0 22.75	.....	.....	.....	+0.552	.....
17 9 1	2	-0 5.48	-0.03	-0 5.51	.....	.....	.....	+0.558	.....	
17 13 53	1	.....	.....	.....	-1 21.69	-0.02	-1 21.71	.....	+1.49	
17 17 32	2	.....	.....	.....	-2 27.23	+0.04	-2 27.27	.....	+1.56	
17 23 2	1	+0 17.97	+0.03	+0 18.00	.....	.....	.....	+0.579	.....	
17 26 36	2	-0 10.03	-0.04	-0 10.07	.....	.....	.....	+0.584	.....	
17 31 37	1	.....	.....	.....	-1 7.41	-0.03	-1 7.44	.....	+1.82	
Oct.14	7 17 13	1	.....	.....	.....	+0 27.61	+0.05	+0 27.66	.....	+3.49
	7 21 40	2	.....	.....	.....	-2 53.37	-0.08	-2 53.45	.....	+3.40
	7 26 27	1	1 2.12	-0.05	-1 2.17	.....	.....	.....	-0.665	.....
	7 29 27	2	+0 12.86	-0.02	+0 12.84	.....	.....	.....	-0.664	.....
	7 32 6	2	+0 12.14	-0.02	+0 12.12	.....	.....	.....	-0.663	.....
	7 34 51	1	1 4.82	-0.04	-1 4.86	.....	.....	.....	-0.662	.....
	16 57 54	1	.....	.....	.....	-1 38.08	-0.04	-1 38.12	.....	+1.32
	17 3 12	2	.....	.....	.....	+1 22.26	+0.05	+1 22.31	.....	+1.41
	17 9 38	2	+0 14.67	.....	.....	.....	.....	.....	+0.593	.....
	17 14 33	2	1 4.24	+0.01	+1 4.25	.....	.....	.....	+0.589	.....
	17 23 27	1	.....	.....	.....	-1 18.50	0.00	-1 18.54	.....	-1.83
	17 28 32	2	.....	.....	.....	+1 41.67	+0.06	+1 41.73	.....	-1.92
	17 34 47	1	-0 49.54	-0.01	-0 49.55	.....	.....	.....	+0.623	.....
17 40 1	2	+0 55.53	+0.01	+0 55.54	.....	.....	.....	+0.629	.....	
17 45 44	2	.....	.....	.....	+1 54.35	+0.06	+1 54.41	.....	+2.26	
Oct.15	6 41 54	1	.....	.....	.....	+0 56.30	+0.04	+0 56.34	.....	+4.14
	6 45 35	2	.....	.....	.....	+1 31.33	+0.11	+1 31.44	.....	+4.05
	6 50 28	2	.....	.....	.....	+1 35.23	+0.11	+1 35.34	.....	+3.95
	6 55 46	1	-0 7.39	0.00	0 7.39	.....	.....	.....	-0.672	.....
	7 0 52	2	-1 11.35	0.03	-1 11.40	.....	.....	.....	-0.672	.....

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date—1900	Comp.	No.	Measured	Ref.	Corrected	Measured	Ref.	Corrected	Parallax Factors
90 Time	Star	Obs.	$\Delta\alpha$		$\Delta\alpha$	$\Delta\delta$		$\Delta\delta$	$\Delta\alpha$ $\Delta\delta$
Oct.15	7 <sup>h</sup> 8 <sup>m</sup> 4 <sup>s</sup>	1	.....	.....	.....	+1' 18'02	+0'04	+1' 18'06	..... +3'58
7 12 30	2	4	.....	.....	.....	+1 54.35	+0.10	+1 54.45	..... +3.47
7 18 23	2	5	-1' 17.22	-0'04	-1' 17.26	.....	.....	.....	..... -0.603
7 22 15	1	5	-0 16.33	+0.01	-0 16.32	.....	.....	.....	..... -0.608
Oct.16	6 38 8	1	5	.....	.....	+0 37.77	+0.06	+0 37.83	..... +4.12
6 42 42	2	5	.....	.....	.....	-1 23.80	0.00	-1 23.80	..... +4.01
6 47 51	1	5	+1 32.42	+0.09	+1 32.51	.....	.....	.....	..... -0.675
6 51 58	2	5	-0 54.12	-0.06	-0 54.18	.....	.....	.....	..... -0.675
6 56 34	2	5	-0 55.87	-0.06	-0 55.93	.....	.....	.....	..... -0.675
7 0 34	1	5	+1 28.14	+0.08	+1 28.22	.....	.....	.....	..... -0.675
7 5 6	3	5	+1 2.98	+0.05	+1 3.03	.....	.....	.....	..... -0.675
7 10 45	3	5	.....	.....	.....	-0 27.07	-0.06	-0 27.13	..... +3.40
7 15 55	1	5	.....	.....	.....	+1 8.81	-0.03	+1 8.78	..... +3.30
7 20 25	2	5	.....	.....	.....	-0 52.83	+0.02	-0 52.81	..... +3.21
7 25 0	2	5	-1 6.07	-0.06	-1 6.13	.....	.....	.....	..... -0.609
7 29 37	3	5	+0 53.66	+0.04	-0 53.70	.....	.....	.....	..... -0.607
7 33 45	1	5	+1 15.91	+0.07	+1 15.98	.....	.....	.....	..... -0.604
12 30 30	7.5	5	.....	.....	.....	-1 51.11	-0.03	-1 51.14	..... -1.17
12 36 28	7.5	5	+0 27.06	+0.01	+0 27.07	.....	.....	.....	..... -0.044
12 50 24	7.5	4	+0 21.16	+0.01	+0 21.17	.....	.....	.....	..... -0.006
12 56 24	7.5	6	.....	.....	.....	-1 31.52	-0.03	-1 31.55	..... -1.19
16 40 15	1	5	.....	.....	.....	+1 15.54	0.00	+1 15.54	..... +1.10
16 45 38	1	5	-1 17.52	-0.06	-1 17.58	.....	.....	.....	..... +0.578
16 50 4	2	5	+0 33.21	0.00	+0 33.21	.....	.....	.....	..... +0.584
16 55 48	2	6	.....	.....	.....	+2 12.48	+0.05	+2 12.53	..... +1.39
17 7 25	1	5	.....	.....	.....	+1 35.32	0.00	+1 35.32	..... +1.61
17 13 4	1	5	.....	.....	.....	-1 28.65	.....	.....	..... +0.615
17 17 54	2	5	-1 28.58	-0.07	-1 28.65	.....	.....	.....	..... +0.620
17 23 28	2	5	+0 22.02	-0.03	+0 21.99	.....	.....	.....	..... +0.92
17 27 15	1	5	.....	.....	.....	+2 32.63	+0.06	+2 32.69	..... +2.01
17 35 54	2	5	+0 15.29	-0.03	+0 15.26	+1 49.71	-0.01	+1 49.70	..... +0.639
17 40 58	1	5	-1 39.37	-0.09	-1 39.46	.....	.....	.....	..... +0.642
17 50 27	1	3	-1 42.96	-0.10	-1 43.06	.....	.....	.....	..... +0.651
Oct.17	7 9 23	10.5	2	.....	.....	-0 1.48	-0.14	-0 1.62	..... +3.28
7 11 3	10.5	3	.....	.....	.....	0 0.00	-0.14	-0 0.14	..... +3.24
7 13 39	10.5	3	.....	.....	.....	+0 2.25	-0.13	+0 2.12	..... +3.18
7 18 6	10.5	5	+3 11.53	+0.14	+3 11.67	.....	.....	.....	..... -0.675
7 24 56	10.5	4	+3 8.58	+0.14	+3 8.72	.....	.....	.....	..... -0.671
7 30 36	10.5	5	.....	.....	.....	+0 15.58	-0.10	+0 15.48	..... +2.80
11 41 39	10	4	.....	.....	.....	-3 13.29	-0.06	-3 13.35	..... -1.05
11 49 11	10	4	-0 37.36	.....	.....	-3 3.89	-0.05	-3 3.94	..... -0.167
11 53 29	10	3	.....	.....	.....	.....	.....	.....	..... -1.11
11 57 26	10	3	-0 9.19	-0.01	-0 9.20	.....	.....	.....	..... -0.145
16 56 33	1	6	.....	.....	.....	-0 58.76	+0.03	-0 58.73	..... +1.49
17 2 46	2	6	.....	.....	.....	+0 41.61	-0.06	+0 41.55	..... +1.61
17 9 40	1	5	+2 2.12	+0.07	+2 2.19	.....	.....	.....	..... +0.622
17 17 44	2	6	-3 3.43	-0.11	-3 3.54	.....	.....	.....	..... +0.633
17 25 6	1	8	+1 55.04	+0.08	+1 55.12	.....	.....	.....	..... +0.639
17 31 31	2	5	-3 9.28	-0.13	-3 9.41	.....	.....	.....	..... +0.645
17 36 39	1	6	.....	.....	.....	-0 30.12	+0.05	-0 30.07	..... +2.30
17 41 33	2	3	.....	.....	.....	+1 8.52	-0.08	+1 8.44	..... +2.41
17 46 22	1	5	+1 46.03	+0.08	+1 46.11	.....	.....	.....	..... +0.658
Oct.18	16 3 5	9.2	5	.....	.....	+3 42.21	+0.10	+3 42.31	..... +0.56
16 10 29	9.2	5	+2 14.59	+0.01	+2 14.60	.....	.....	.....	..... +0.544
16 17 14	9.2	5	.....	.....	.....	+3 51.53	+0.10	+3 51.63	..... +0.80
Oct.25	6 18 50	1	4	.....	.....	+1 31.31	-0.02	+1 31.29	..... +3.30
6 24 7	1	4	+1 16.62	+0.08	+1 16.70	.....	.....	.....	..... -0.710
6 29 17	1	4	+1 13.37	+0.08	+1 13.45	.....	.....	.....	..... -0.709
6 34 4	1	4	.....	.....	.....	+1 40.39	-0.01	+1 40.38	..... +2.94
6 40 30	2	5	.....	.....	.....	-1 34.56	+0.07	-1 34.49	..... +2.80
6 46 4	2	5	-4 2.77	-0.19	-4 2.96	.....	.....	.....	..... -0.701
6 52 28	2	4	-4 6.66	-0.19	-4 6.85	.....	.....	.....	..... -0.699
6 57 19	2	4	.....	.....	.....	-1 24.50	+0.07	-1 24.43	..... +2.43
7 45 53	1	5	.....	.....	.....	+2 23.89	+0.04	+2 23.93	..... +1.41
7 52 32	1	5	+0 22.50	+0.05	+0 22.55	.....	.....	.....	..... -0.637
11 31 51	1	5	.....	.....	.....	-2 24.79	-0.04	-2 24.83	..... -1.52
11 39 9	1	4	+1 18.12	+0.02	+1 18.14	.....	.....	.....	..... -0.078

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date—1900 to Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	$\Delta\delta$
Oct 25 11 <sup>h</sup> 45 <sup>m</sup> 21 <sup>s</sup>	1	4	.....	.....	.....	-2 17.52	-0.04	-2 17.56	.....	-1.55
16 31 53	1	5	.....	.....	.....	+0 11.91	0.00	+0 11.91	.....	+1.58
16 38 51	2	5	.....	.....	.....	-0 48.04	+0.05	-0 48.99	.....	+1.72
16 46 1	2	5	+2 34.81	+0.10	+2 34.91	.....	.....	.....	+06.74	.....
16 54 6	1	5	-2 6.34	-0.08	-2 6.42	.....	.....	.....	+0.682	.....
17 10 38	1	5	.....	.....	.....	+0 31.33	-0.08	+0 31.25	.....	+2.45
17 17 5	1	5	.....	.....	.....	-0 30.35	+0.07	-0 30.28	.....	+2.56
17 24 41	2	5	+2 10.72	+0.10	+2 10.82	.....	.....	.....	+0.704	.....
17 29 55	1	5	-2 28.35	-0.11	-2 28.46	.....	.....	.....	+0.706	.....
17 38 38	1	6	.....	.....	.....	+0 44.89	-0.11	+0 44.78	.....	+3.03
17 44 43	1	6	.....	.....	.....	-0 16.73	+0.08	-0 16.65	.....	+3.16
17 51 4	2	4	+1 54.60	+0.09	+1 54.69	.....	.....	.....	+0.712	.....
Oct 26 5 55 45	1	5	.....	.....	.....	-2 0.37	-0.12	-2 0.49	.....	+3.69
6 1 18	1	5	+1 28.04	+0.03	+1 28.07	.....	.....	.....	-0.716	.....
6 7 47	1	5	.....	.....	.....	-1 53.41	-0.11	-1 53.52	.....	+3.42
6 14 10	2	5	.....	.....	.....	+0 30.35	+0.18	+0 30.53	.....	+3.26
6 21 8	1	5	+1 15.93	+0.01	+1 15.94	.....	.....	.....	-0.713	.....
6 27 9	2	5	-4 12.30	-0.17	-4 12.47	.....	.....	.....	-0.711	.....
7 38 2	1	5	.....	.....	.....	-1 1.24	-0.03	-1 1.27	.....	+1.43
7 44 30	1	5	+0 23.10	-0.01	+0 23.09	.....	.....	.....	-0.644	.....
7 48 40	1	5	+0 20.49	-0.01	+0 20.48	.....	.....	.....	-0.639	.....
7 53 22	1	5	.....	.....	.....	-0 52.62	-0.02	-0 52.64	.....	+1.13
9 0 2	1	5	.....	.....	.....	-0 15.18	0.00	-0 15.18	.....	0.10
9 3 49	1	5	-0 28.81	-0.01	-0 28.82	.....	.....	.....	-0.497	.....
11 56 26	1	5	.....	.....	.....	+1 20.30	+0.02	+1 20.32	.....	-1.59
12 1 51	1	5	-2 29.04	-0.04	-2 29.08	.....	.....	.....	+0.006	.....
12 7 32	1	4	-2 32.70	-0.04	-2 32.74	.....	.....	.....	+0.025	.....
12 11 35	1	4	.....	.....	.....	+1 28.33	+0.03	+1 28.36	.....	-1.58
16 25 7	2	4	.....	.....	.....	+0 27.61	0.00	+0 27.61	.....	+1.54
16 30 15	2	4	.....	.....	.....	-0 31.67	-0.06	-0 31.73	.....	+1.64
16 35 3	3	4	.....	.....	.....	-1 43.14	-0.03	-1 43.17	.....	+1.75
16 41 41	3	4	-0 8.76	+0.02	-0 8.74	.....	.....	.....	+0.676	.....
16 46 3	1	4	-0 37.71	-0.03	-0 37.74	.....	.....	.....	+0.681	.....
16 50 49	2	4	-2 10.24	-0.07	-2 10.31	.....	.....	.....	+0.685	.....
17 2 35	3	4	.....	.....	.....	-1 30.72	-0.03	-1 30.75	.....	+2.33
17 7 59	2	4	.....	.....	.....	-0 14.66	-0.07	-0 14.73	.....	+2.44
17 36 14	1	3	.....	.....	.....	+1 0.44	+0.01	+1 0.45	.....	+3.08
Oct 27 9 7 29	1	5	.....	.....	.....	-1 56.21	-0.03	-1 56.24	.....	-0.39
9 14 13	1	5	-0 14.56	-0.03	-0 14.59	.....	.....	.....	-0.451	.....
9 25 38	1	4	.....	.....	.....	1 46.80	-0.03	-1 46.83	.....	-0.64
9 30 0	1	4	-0 25.16	-0.03	-0 25.19	.....	.....	.....	-0.413	.....
9 34 11	2	4	+0 45.26	+0.03	+0 45.29	.....	.....	.....	-0.400	.....
9 37 57	2	4	.....	.....	.....	+1 9.09	+0.01	+1 9.10	.....	0.79
9 43 8	2	4	+0 39.32	+0.02	+0 39.34	.....	.....	.....	-0.379	.....
9 47 29	2	4	.....	.....	.....	+1 13.58	+0.02	+1 13.60	.....	-0.91
Oct 30 15 52 1	11	5	.....	.....	.....	+1 6.02	+0.05	+1 6.07	.....	+1.25
15 59 18	11	5	+1 10.47	+0.02	+1 10.49	.....	.....	.....	+0.667	.....
16 12 23	11	4	.....	.....	.....	+1 13.39	+0.05	+1 13.44	.....	+1.71
Nov. 1 5 55 12	1	4	.....	.....	.....	-0 25.82	+0.02	-0 25.80	.....	+2.84
5 58 46	1	4	-0 42.59	-0.04	-0 42.63	.....	.....	.....	-0.725	.....
6 2 21	2	5	+0 26.48	+0.04	+0 26.52	.....	.....	.....	-0.724	.....
6 6 28	3	5	+0 10.69	+0.03	+0 10.72	.....	.....	.....	-0.721	.....
6 10 14	3	5	+0 7.85	+0.03	+0 7.88	.....	.....	.....	-0.719	.....
6 13 46	2	5	+0 18.34	+0.04	+0 18.38	.....	.....	.....	-0.717	.....
6 17 37	2	5	.....	.....	.....	+1 30.22	+0.02	+1 30.24	.....	+2.32
6 21 32	3	5	.....	.....	.....	-1 54.22	.....	.....	.....	+2.12
6 30 37	1	5	.....	.....	.....	-0 12.89	+0.02	-0 12.87	.....	+2.03
6 36 46	4	5	.....	.....	.....	+3 44.51	+0.07	+3 44.58	.....	+1.90
6 42 10	4	5	-0 5.49	+0.07	-0 5.42	.....	.....	.....	-0.692	.....
6 51 11	4	5	-0 11.96	+0.06	-0 11.90	.....	.....	.....	-0.683	.....
6 56 34	4	5	.....	.....	.....	+3 51.84	+0.08	+3 51.92	.....	+1.47
8 10 10	1	5	.....	.....	.....	+0 23.45	+0.04	+0 23.49	.....	0.00
8 15 32	3	5	.....	.....	.....	+2 13.17	+0.06	+2 13.23	.....	0.05
8 20 22	2	5	.....	.....	.....	-1 10.91	+0.01	-1 10.90	.....	0.10
8 26 7	1	5	-2 32.02	-0.05	-2 32.07	.....	.....	.....	-0.519	.....
8 31 8	3	5	-1 24.59	0.00	-1 24.59	.....	.....	.....	-0.507	.....
8 35 51	2	5	1 11.02	-0.05	-1 11.07	.....	.....	.....	-0.495	.....

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date—1900	Comp.	No.	Measured	Ref.	Corrected	Measured	Ref.	Corrected	Parallax Factors
90 Time	Star	Obs.	$\Delta\alpha$		$\Delta\alpha$	$\Delta\delta$		$\Delta\delta$	$\Delta\alpha$ $\Delta\delta$
Nov. 1									
8 <sup>h</sup> 43 <sup>m</sup> 44 <sup>s</sup>	1	4	-2' 45.47	-0.05	-2' 45.52	.....	.....	.....	-0.476
8 47 49	3	4	-1 37.28	0.00	-1 37.28	.....	.....	.....	-0.466
8 50 55	2	4	-1 52.15	-0.05	-1 52.20	.....	.....	.....	-0.453
8 54 29	1	4	.....	.....	.....	+0' 38.53	+0.05	+0' 38.58	-0.765
8 57 17	3	4	.....	.....	.....	+2 28.09	+0.06	+2 28.15	-0.69
9 0 21	2	4	.....	.....	.....	-0 57.25	0.00	-0 57.25	-0.73
16 46 42	1	5	.....	.....	.....	-1 25.00	-0.13	-1 25.13	+2.65
16 51 45	2	5	.....	.....	.....	+2 39.92	+0.01	+2 39.93	+2.76
16 58 49	1	5	-2 50.09	-0.10	-2 50.19	.....	.....	.....	+0.728
17 5 10	2	5	-1 42.32	-0.12	-1 42.44	.....	.....	.....	+0.730
17 12 38	1	5	.....	.....	.....	-1 18.52	-0.17	-1 18.69	+3.24
17 17 48	2	5	.....	.....	.....	+2 46.34	0.02	+2 46.32	+3.36
17 30 17	1	5	-3 12.61	-0.14	-3 12.75	.....	.....	.....	+0.733
17 35 34	2	5	-2 8.14	-0.15	-2 8.29	.....	.....	.....	+0.732
17 49 53	3	6	+1 45.06	+0.10	+1 45.16	.....	.....	.....	+0.728
17 56 9	3	6	.....	.....	.....	-0 18.12	+0.10	-0 18.02	+4.22
18 1 29	3	6	+1 36.93	+0.09	+1 37.02	.....	.....	.....	+0.723
Nov. 2									
5 42 43	1	6	.....	.....	.....	-0 1.56	-0.03	-0 1.59	+2.95
5 47 35	1	6	+0 43.86	+0.03	+0 43.89	.....	.....	.....	-0.731
5 51 33	1	4	+0 40.94	+0.03	+0 40.93	.....	.....	.....	-0.729
5 55 10	2	5	-0 39.14	-0.03	-0 39.17	.....	.....	.....	-0.727
5 59 5	1	5	.....	.....	.....	+0 3.85	-0.02	+0 3.83	+2.59
6 2 51	2	4	.....	.....	.....	-0 0.77	+0.03	-0 0.74	+2.54
6 9 7	1	5	+0 28.03	+0.02	+0 28.05	.....	.....	.....	-0.720
6 12 55	1	5	+0 25.12	+0.02	+0 25.14	.....	.....	.....	-0.717
6 16 12	1	4	.....	.....	.....	+0 9.63	-0.01	+0 9.62	+2.21
6 18 42	1	4	.....	.....	.....	+0 10.49	-0.01	+0 10.48	+2.14
6 27 19	3	6	.....	.....	.....	+2 14.91	+0.02	+2 14.93	+1.97
6 31 43	3	5	.....	.....	.....	+2 16.39	+0.02	+2 16.41	+1.86
6 35 52	3	5	+0 47.73	+0.07	+0 47.80	.....	.....	.....	-0.686
6 39 2	3	5	+0 45.29	+0.07	+0 45.36	.....	.....	.....	-0.693
8 9 22	1	5	.....	.....	.....	+0 46.68	+0.03	+0 46.71	-0.05
8 13 44	3	5	.....	.....	.....	+2 49.20	+0.07	+2 49.27	-0.13
8 18 42	1	5	-1 10.39	-0.02	-1 10.41	.....	.....	.....	-0.523
8 23 16	3	5	-0 34.95	+0.04	-0 34.91	.....	.....	.....	-0.514
8 27 50	3	5	-0 38.45	+0.04	0 38.41	.....	.....	.....	-0.502
8 31 37	1	5	-1 19.95	-0.02	-1 19.97	.....	.....	.....	-0.492
8 41 3	4	4	.....	.....	.....	+1 51.21	+0.02	+1 51.23	-0.54
8 44 33	4	4	+1 37.03	+0.06	+1 37.09	.....	.....	.....	-0.460
12 17 3	1	5	+2 4.52	+0.05	+2 4.57	.....	.....	.....	+0.187
12 24 8	2	5	+2 45.61	+0.05	+2 45.66	.....	.....	.....	+0.006
12 31 15	1	5	.....	.....	.....	-1 36.33	-0.02	-1 36.35	-1.51
12 35 53	2	5	.....	.....	.....	-0 32.12	0.00	-0 32.12	-1.47
12 39 46	2	5	.....	.....	.....	-0 31.14	+0.01	-0 31.13	-1.44
12 43 43	1	5	.....	.....	.....	-1 33.23	-0.02	-1 33.25	-1.41
12 55 0	1	5	+1 35.18	+0.04	+1 35.22	.....	.....	.....	+0.299
12 58 49	2	5	+2 17.96	+0.05	+2 18.01	.....	.....	.....	+0.311
16 56 7	1	5	.....	.....	.....	-0 37.88	-0.08	-0 37.96	+2.98
17 0 42	2	5	.....	.....	.....	+0 26.55	-0.02	+0 26.53	+3.09
17 4 41	3	4	.....	.....	.....	-1 8.23	+0.01	-1 8.22	+3.17
17 10 52	1	5	-1 40.54	-0.07	-1 40.61	.....	.....	.....	+0.736
17 15 23	2	5	-0 57.98	-0.05	-0 58.03	.....	.....	.....	+0.736
17 19 46	3	5	+0 53.26	+0.06	+0 53.32	.....	.....	.....	+0.736
17 23 54	3	5	+0 50.22	+0.06	+0 50.28	.....	.....	.....	+0.736
17 28 1	2	5	-1 7.19	-0.06	-1 7.25	.....	.....	.....	+0.736
17 31 31	1	5	-1 56.05	-0.09	-1 56.14	.....	.....	.....	+0.735
17 35 20	1	5	.....	.....	.....	-0 29.88	-0.12	-0 30.00	+3.87
17 38 38	2	6	.....	.....	.....	+0 33.97	-0.05	+0 33.92	+3.96
17 42 35	3	7	.....	.....	.....	-1 0.64	+0.02	-1 0.62	+4.05
17 47 23	3	4	+0 59.77	+0.06	+0 59.83	.....	.....	.....	+0.730
17 50 29	2	4	.....	.....	.....	+0 35.99	-0.06	+0 35.93	+4.24
17 55 18	1	7	.....	.....	.....	-0 25.90	-0.14	-0 26.04	+4.32
18 4 24	2	4	.....	.....	.....	+0 39.02	-0.07	+0 38.95	+4.47
18 8 0	2	4	-1 36.71	-0.10	-1 36.81	.....	.....	.....	+0.719
Nov. 3									
5 39 59	1	6	-0 2.97	+0.01	-0 2.96	.....	.....	.....	-0.733
5 44 31	1	6	-0 6.17	+0.01	-0 6.16	.....	.....	.....	-0.731
5 49 9	1	5	.....	.....	.....	+0 38.91	+0.02	+0 38.93	+2.68
5 52 5	1	5	.....	.....	.....	+0 39.91	+0.02	+0 39.93	+2.61
5 57 37	2	6	.....	.....	.....	-2 4.04	+0.07	-2 3.97	+2.46

MICROMETRICAL OBSERVATIONS OF EROS *Continued*

Date	Time	Comp. Stat.	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	Parallax Factors $\Delta\delta$
Nov. 3	6 <sup>h</sup> 2 <sup>m</sup> 27 <sup>s</sup>	2	6	.....	.....	.....	2 2' 57"	+0.06	2 2' 51"	.....	+2.37
	6 7 14	2	6	-0 14.45	-0.08	-0 14.53	.....	.....	.....	-0.717	.....
	6 11 37	2	6	-0 17.52	-0.08	-0 17.60	.....	.....	.....	-0.714	.....
	6 16 46	1	5	-0 30.38	0.00	-0 30.38	.....	.....	.....	-0.709	.....
	6 20 24	1	5	-0 32.77	-0.01	-0 32.78	.....	.....	.....	-0.706	.....
	6 24 48	1	4	.....	.....	.....	+0 49.40	+0.03	+0 49.43	.....	+1.87
	6 28 7	1	4	.....	.....	.....	+0 50.52	+0.03	+0 50.55	.....	+1.81
	6 34 28	1	5	.....	.....	.....	+1 9.55	+0.04	+1 9.59	.....	+1.68
	6 38 10	2	5	.....	.....	.....	-1 35.27	0.00	-1 35.27	.....	+1.59
	6 43 5	1	5	.....	.....	.....	+1 11.85	+0.04	+1 11.89	.....	+1.48
	6 46 56	2	5	.....	.....	.....	-1 32.56	0.00	-1 32.56	.....	+1.40
	6 52 10	1	5	1 43.67	-0.02	-1 43.69	.....	.....	.....	-0.564	.....
	6 55 57	2	5	-1 37.35	-0.06	-1 37.41	.....	.....	.....	-0.561	.....
	8 0 50	1	5	.....	.....	.....	+1 50.39	+0.04	+1 50.43	.....	+1.11
	8 4 41	2	5	-1 44.35	-0.06	-1 44.41	.....	.....	.....	-0.542	.....
	8 20 15	1	5	.....	.....	.....	+1 22.09	+0.05	+1 22.14	.....	+0.73
	8 23 56	2	5	.....	.....	.....	-1 22.74	0.00	-1 22.74	.....	+0.65
	8 28 36	1	5	-2 12.32	-0.03	-2 12.35	.....	.....	.....	-0.486	.....
	8 32 35	2	5	-2 6.30	-0.06	-2 6.36	.....	.....	.....	-0.476	.....
	10 52 46	10	5	.....	.....	.....	-1 59.16	0.03	-1 59.19	.....	-1.76
	10 59 17	10	5	.....	.....	.....	1 57.64	0.03	1 57.67	.....	-1.77
	11 5 32	10	5	-1 12.89	-0.02	-1 12.91	.....	.....	.....	-0.022	.....
	11 10 56	10	5	-1 17.72	0.02	-1 17.74	.....	.....	.....	-0.006	.....
	11 18 34	9.5	5	-4 18.67	-0.08	-4 18.75	.....	.....	.....	+0.019	.....
	11 31 43	9.5	3	.....	.....	.....	+0 35.38	+0.01	+0 35.39	.....	1.76
	16 18 15	1	5	.....	.....	.....	-1 34.16	-0.02	-1 34.18	.....	+2.24
	16 23 14	2	5	.....	.....	.....	-1 8.82	+0.08	-1 8.74	.....	+2.35
	16 29 15	1	6	-0 2.85	+0.03	+0 2.88	.....	.....	.....	+0.725	.....
	16 35 22	2	5	+2 46.76	+0.13	+2 46.89	.....	.....	.....	+0.728	.....
	16 40 11	1	5	-0 5.19	+0.02	-0 5.17	.....	.....	.....	+0.730	.....
	16 45 45	2	5	+2 39.22	+0.13	+2 39.35	.....	.....	.....	+0.733	.....
	16 58 56	1	5	.....	.....	.....	-1 27.66	-0.05	-1 27.71	.....	-3.17
	17 3 0	2	5	.....	.....	.....	-1 2.24	+0.09	-1 2.15	.....	-3.26
	17 17 34	3	5	.....	.....	.....	+1 47.91	+0.12	+1 48.03	.....	-3.61
	17 21 30	1	5	.....	.....	.....	-1 23.89	-0.07	-1 23.96	.....	-3.68
	17 24 57	2	5	.....	.....	.....	-0 58.71	+0.09	-0 58.62	.....	-3.77
	17 30 35	1	5	-0 42.36	-0.02	-0 42.38	.....	.....	.....	+0.735	.....
	17 35 9	3	5	+1 5.09	+0.04	+1 5.13	.....	.....	.....	+0.734	.....
	17 39 28	2	5	+1 59.70	+0.12	+1 59.82	.....	.....	.....	+0.732	.....
	17 45 13	2	3	+1 55.16	+0.11	+1 55.27	.....	.....	.....	+0.730	.....
	17 47 37	1	3	-0 54.48	0.04	-0 54.52	.....	.....	.....	+0.728	.....
	17 50 39	3	4	+0 53.74	+0.03	+0 53.77	.....	.....	.....	+0.727	.....
	17 54 1	3	3	.....	.....	.....	+1 53.69	+0.12	+1 53.81	.....	+1.13
	17 56 44	1	3	.....	.....	.....	-1 18.20	-0.12	-1 18.32	.....	+1.19
	17 59 49	2	4	.....	.....	.....	0 53.69	+0.08	-0 53.01	.....	+1.56
	18 3 51	2	4	+1 41.71	+0.10	+1 41.81	.....	.....	.....	+0.718	.....
	18 6 36	1	3	-1 8.31	-0.06	-1 8.37	.....	.....	.....	+0.716	.....
Nov. 4	6 2 45	1	5	.....	.....	.....	-0 30.09	+0.06	-0 30.03	.....	+2.21
	6 6 40	2	5	.....	.....	.....	-1 4.12	+0.06	-1 4.06	.....	+2.12
	6 11 7	1	6	-2 9.21	-0.09	2 9.30	.....	.....	.....	-0.711	.....
	6 14 55	2	6	-2 31.02	-0.11	2 31.13	.....	.....	.....	-0.708	.....
	6 20 4	1	5	-2 16.07	-0.09	2 16.16	.....	.....	.....	-0.703	.....
	6 23 22	2	6	-2 37.66	-0.11	2 37.77	.....	.....	.....	-0.700	.....
	6 28 34	1	5	.....	.....	.....	-0 23.83	+0.06	0 23.77	.....	+1.65
	6 32 6	2	5	.....	.....	.....	-0 58.03	+0.06	-0 57.97	.....	+1.59
	6 37 9	4	5	.....	.....	.....	+1 24.18	-0.05	+1 24.13	.....	+0.80
	6 41 53	4	5	.....	.....	.....	-1 55.47	-0.09	-1 55.56	.....	+0.70
	6 47 21	2	3	+3 42.47	+0.13	+3 42.60	.....	.....	.....	-0.618	.....
	6 51 30	4	4	+3 1.62	+0.05	+3 1.67	.....	.....	.....	-0.609	.....
	6 55 36	1	5	-3 14.58	-0.09	-3 14.67	.....	.....	.....	-0.592	.....
	6 59 41	0	4	-3 37.95	-0.10	-3 38.05	.....	.....	.....	-0.580	.....
	6 59 47	5	1	.....	.....	.....	-0 3.91	+0.05	-0 3.86	.....	+0.08
	6 59 51	4	5	.....	.....	.....	-0 38.09	+0.05	-0 38.04	.....	+0.01
	6 59 55	3	5	.....	.....	.....	-0 36.94	+0.05	-0 36.89	.....	0.06
	6 59 59	55	8	.....	.....	.....	-0 1.25	+0.05	-0 1.20	.....	0.12
	6 59 59	55	8	.....	.....	.....	-1 37.73	-0.06	-1 37.79	.....	0.22
	6 59 59	55	8	.....	.....	.....	-1 42.47	-0.06	-1 42.53	.....	0.30
	8 10 39	4	5	.....	.....	.....	.....	.....	.....	-0.504	.....
	8 16 26	2	5	+3 2.22	+0.05	+3 2.27	.....	.....	.....	-0.494	.....
	8 20 25	4	5	+2 4.93	+0.02	2 4.95	.....	.....	.....	-0.482	.....
	8 24 47	1	5	-3 52.86	-0.09	-3 52.95	.....	.....	.....	.....	.....

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date—1900 to Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$	
Nov. 4	8 <sup>h</sup> 30 <sup>m</sup> 16 <sup>s</sup>	2	5	-4' 17.76	-0.06	-4' 17.82			-0.470	
10	26 35	4	5			-1' 12.73	-0.02	-1' 12.75	-1.71	
10	30 43	3	5			+2 9.17	+0.04	+2 9.21	-1.73	
10	35 44	4	5	+0 19.74	0.00	+0 19.74			-0.100	
10	40 12	3	5	+1 3.06	+0.02	+1 3.08			-0.087	
16	21 47	1	5			2 41.02	-0.05	-2 41.07	+2.46	
16	27 51	2	5			+1 12.88	+0.12	+1 13.00	+2.60	
16	32 39	2	5			+1 13.50	+0.12	+1 13.62	+2.71	
16	37 24	1	5			-2 38.99	-0.06	-2 39.05	+2.81	
16	43 21	1	4	+0 1.32	+0.05	+0 1.37			+0.735	
16	49 20	2	6	+2 4.33	+0.06	+2 4.39			+0.737	
15	55 14	1	5	-0 7.94	+0.04	-0 7.90			+0.739	
17	0 41	2	5	+1 56.01	+0.07	+1 56.08			+0.739	
17	8 46	1	5							
17	15 26	2	5			-2 35.24	-0.08	-2 35.32	+3.56	
17	22 5	2	6			+1 18.84	+0.12	+1 18.96	+3.68	
17	27 26	1	6			+1 19.68	+0.13	+1 19.81	+3.84	
17	42 34	1	5	-0 43.05	-0.01	-0 43.06	-2 32.93	-0.11	-2 33.04	+3.95
17	47 45	2	6	+1 21.60	+0.07	+1 21.67			+0.730	
17	53 21	2	5			+1 23.44	+0.14	+1 23.58	+0.727	
17	57 37	2	6			+1 39.33	+0.14	+1 39.47	+4.49	
18	2 23	2	5	+1 10.77	+0.06	+1 10.83			+4.65	
18	6 51	1	7	-1 1.15	-0.05	-1 1.20			+0.717	
18	11 32	1	2	-1 3.54	-0.06	-1 3.60			+0.713	
									+0.709	
Nov. 5	5 37 14	1	5	-0 29.98	+0.09	-0 29.89			-0.732	
5	41 22	2	6	+0 59.50	+0.10	+0 59.60			-0.730	
5	45 56	1	5			+2 23.48	+0.07	+2 23.55	+2.48	
5	49 6	2	5			+2 47.63	+0.02	+2 47.65	+2.41	
5	53 34	3	5			+2 26.24	+0.06	+2 26.30	+2.29	
5	57 24	4	5			+1 38.32	-0.10	+1 38.22	+2.23	
6	2 38 4	5	5	-4 7.51	+0.06	-4 7.45			-0.715	
6	6 32	3	5	+3 15.47	+0.17	+3 15.64			-0.712	
6	28 11	5	5	+1 54.60	+0.04	+1 54.64			-0.690	
6	32 47	5	5			-1 2.81	-0.07	-1 2.88	+1.44	
7	11 55	3	5			+2 42.68	0.00	+2 42.68	+0.65	
7	17 0	6	5			+1 23.23	-0.04	+1 23.19	+0.54	
7	22 7	3	5	+2 16.34	+0.11	+2 16.45			-0.609	
7	26 41	6	5	+3 45.71	+0.12	+3 45.83			-0.599	
7	32 57	7	5	+3 45.96	+0.16	+3 46.12			-0.588	
7	38 42	7	5			+3 28.83	0.00	+3 28.83	+0.14	
7	45 47	7	5			+3 30.33	0.00	+3 30.33	+0.02	
7	51 58	7	6	+3 31.08	+0.14	+3 31.22			-0.548	
10	33 4	6	5			+1 59.10	+0.03	+1 59.13	1.77	
10	40 40	6	5	+1 8.58	+0.02	+1 8.60			-0.067	
10	45 36	6	5	+1 4.71	+0.02	+1 4.73			-0.051	
10	50 58	6	5			+2 1.56	+0.03	+2 1.59	-1.81	
Nov. 6	10 23 8	12	5			+1 24.06	+0.02	+1 24.08	-1.91	
10	28 2	12	5	+1 11.76	+0.02	+1 11.78			-0.087	
Nov. 7	13 8 1	1	5			-0 15.62	+0.01	-0 15.61	-0.87	
13	10 56	2	5			2 16.72	-0.02	-2 16.74	-0.83	
13	14 3	1	5	+1 48.09	+0.04	+1 48.13			+0.442	
13	16 53	2	5	+1 49.54	+0.07	+1 49.61			+0.449	
Nov. 8	5 50 47	1	5	+0 46.69	+0.01	+0 46.70			-0.712	
5	53 47	2	5	-0 35.46	-0.01	-0 35.47			-0.709	
5	57 2	3	5	+0 48.14	+0.05	+0 48.19			-0.705	
6	0 29	1	5			-0 47.38	-0.02	-0 47.40	+1.74	
6	3 39	2	5			+0 28.75	+0.03	+0 28.78	+1.68	
6	6 28	3	5			+0 54.14	0.00	+0 54.14	+1.62	
6	10 39	1	5	+0 31.40	0.00	+0 31.40			-0.691	
6	13 53	2	5	-0 51.15	-0.02	-0 51.17			-0.686	
6	16 43	3	5	+0 33.13	+0.03	+0 33.16			-0.683	
6	21 28	1	5			-0 45.62	-0.02	-0 45.64	+1.28	
6	24 45	2	5			+0 30.50	+0.03	+0 30.53	+1.22	
6	27 46	3	5			+0 55.80	0.00	+0 55.80	+1.16	
7	1 24	3	5			+0 58.74	+0.01	+0 58.75	+0.49	
7	5 8	1	5			-0 41.74	-0.01	-0 41.75	+0.37	

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	$\Delta\delta$
Nov. 8											
7	9 <sup>m</sup> 15	2	5	.....	.....	.....	+0 34'23	+0.04	+0 34'27	.....	+0.34
13	38	1	5	-0' 18.45	-0.02	-0' 18.47	.....	.....	.....	-0.591	.....
17	10	3	5	+0 15.11	+0.02	+0 15.13	.....	.....	.....	-0.583	.....
17	21	1	5	-1 44.41	-0.03	-1 44.44	.....	.....	.....	-0.575	.....
17	21	1	5	.....	.....	.....	-0 40.31	0.00	-0 40.31	.....	+0.01
17	26	51	1	.....	.....	.....	+0 35.80	+0.04	+0 35.84	.....	-0.04
17	30	26	2	.....	.....	.....	+1 1.13	+0.03	+1 1.16	.....	-0.11
17	34	36	3	.....	.....	.....	.....	.....	.....	-0.525	.....
17	44	16	1	.....	.....	.....	.....	.....	.....	-0.515	.....
17	47	53	3	-0 42.57	-0.03	-0 42.60	.....	.....	.....	-0.506	.....
17	52	24	2	0 39.59	0.00	0 39.59	.....	.....	.....	-0.464	.....
17	52	24	2	2 9.05	-0.04	2 9.09	.....	.....	.....	-0.457	.....
17	52	24	2	1 2.99	-0.03	1 3.02	.....	.....	.....	.....	.....
8	9	28	1	0 58.82	-0.01	0 58.83	.....	.....	.....	.....	.....
8	12	4	3	.....	.....	.....	-0 36.67	0.00	-0 36.67	.....	0.76
8	15	42	1	.....	.....	.....	+1 4.18	+0.03	+1 4.21	.....	-0.79
8	18	14	3	.....	.....	.....	-0 29.57	-0.02	-0 29.59	.....	1.78
11	12	38	1	.....	.....	.....	+1 11.55	+0.01	+1 11.56	.....	1.77
11	16	27	3	.....	.....	.....	.....	.....	.....	+0.123	.....
11	21	24	1	-3 41.32	-0.06	-3 41.38	.....	.....	.....	+0.138	.....
11	25	48	3	-3 37.99	-0.07	-3 38.06	.....	.....	.....	.....	.....
11	33	1	1	.....	.....	.....	-0 29.18	-0.02	0 29.20	.....	-1.70
11	38	9	3	.....	.....	.....	+1 11.99	+0.01	+1 12.00	.....	1.67
16	16	19	1	.....	.....	.....	+1 13.05	+0.03	+1 13.08	.....	+2.83
16	21	12	1	-0 3.15	-0.02	0 3.17	.....	.....	.....	+0.739	.....
16	26	22	1	.....	.....	.....	+1 12.48	+0.02	+1 12.50	.....	+3.05
16	30	28	1	.....	.....	.....	+1 12.19	+0.02	+1 12.21	.....	+3.17
16	35	12	1	-0 13.48	-0.03	0 13.51	.....	.....	.....	+0.742	.....
16	57	56	2	.....	.....	.....	-1 23.66	+0.01	-1 23.65	.....	+3.82
17	2	12	1	.....	.....	.....	+1 10.69	-0.01	+1 10.68	.....	+3.91
17	10	17	2	+0 58.44	+0.07	+0 58.51	.....	.....	.....	+0.737	.....
17	30	59	1	-0 54.89	-0.06	-0 54.95	.....	.....	.....	+0.726	.....
17	52	6	3	-1 10.65	-0.08	-1 10.73	.....	.....	.....	+0.687	.....
Nov. 10											
5	44	11	1	-4 19.79	-0.15	-4 19.94	.....	.....	.....	-0.706	.....
5	51	31	1	.....	.....	.....	-0 0.00	+0.13	+0 0.07	.....	+1.67
5	56	36	1	1 29.20	-0.15	-4 29.35	.....	.....	.....	-0.693	.....
6	3	18	1	.....	.....	.....	-0 0.24	+0.12	0 0.12	.....	+1.39
7	16	28	1	.....	.....	.....	-0 0.26	+0.08	-0 0.18	.....	0.01
14	51	36	1	.....	.....	.....	-0 32.77	-0.01	-0 32.78	.....	+1.22
14	56	13	2	.....	.....	.....	-0 32.96	-0.01	-0 32.97	.....	+1.32
15	2	56	1	0 16.40	0.00	0 16.40	.....	.....	.....	+0.688	.....
15	15	50	1	0 27.38	0.00	0 27.38	.....	.....	.....	+0.703	.....
15	37	52	2	0 13.71	0.00	0 13.71	.....	.....	.....	+0.723	.....
16	41	45	1	1 1.83	-0.04	1 1.87	.....	.....	.....	+0.742	.....
16	45	44	1	1 35.20	-0.07	1 35.27	.....	.....	.....	+0.740	.....
16	49	30	3	0 40.76	-0.05	0 40.81	.....	.....	.....	+0.739	.....
16	54	1	2	.....	.....	.....	-0 48.81	-0.08	-0 48.89	.....	+1.00
16	57	57	1	.....	.....	.....	-0 49.63	-0.11	-0 49.74	.....	+1.09
17	3	9	3	.....	.....	.....	+1 8.12	0.00	+1 8.12	.....	+1.21
Nov. 11											
6	28	13	9.6	-1 37.64	-0.04	-1 37.68	.....	.....	.....	-0.640	.....
6	33	3	9.6	.....	.....	.....	+0 35.15	+0.05	+0 35.20	.....	+0.68
6	37	10	9.6	-1 44.79	-0.04	-1 44.83	.....	.....	.....	-0.624	.....
6	41	33	9.6	-1 47.96	-0.04	-1 48.00	.....	.....	.....	-0.617	.....
6	45	59	9.6	.....	.....	.....	+0 34.22	+0.04	+0 34.26	.....	+0.43
6	49	17	9.6	.....	.....	.....	+0 34.19	+0.04	+0 34.23	.....	+0.37
7	9	2	9.8	.....	.....	.....	+0 33.30	+0.04	0 33.31	.....	+0.01
7	14	5	9.8	-2 13.56	-0.05	-2 13.61	.....	.....	.....	-0.551	.....
7	18	59	9.8	-2 17.26	-0.05	-2 17.31	.....	.....	.....	-0.540	.....
7	23	44	9.8	.....	.....	.....	+0 32.42	+0.04	+0 32.46	.....	0.22
7	46	23	9.8	.....	.....	.....	+0 31.94	+0.04	+0 31.98	.....	0.13
7	51	57	9.8	-2 43.66	-0.05	-2 43.71	.....	.....	.....	-0.489	.....
7	59	37	9.8	-2 49.50	-0.05	-2 49.55	.....	.....	.....	-0.469	.....
8	5	13	9.8	.....	.....	.....	+0 30.04	+0.04	+0 30.08	.....	0.86
Nov. 13											
5	48	40	1	-2 40.96	-0.11	-2 41.07	.....	.....	.....	-0.678	.....
5	53	26	2	3 15.45	-0.07	-3 15.52	.....	.....	.....	-0.671	.....
6	9	33	1	.....	.....	.....	-1 21.43	+0.04	-2 21.39	.....	+1.12
6	3	57	2	.....	.....	.....	+1 39.71	+0.01	+1 39.72	.....	1.06
6	10	11	1	-2 57.69	-0.11	-2 57.80	.....	.....	.....	-0.647	.....
6	14	4	2	-3 30.83	-0.07	-3 30.90	.....	.....	.....	-0.643	.....
6	19	3	1	.....	.....	.....	-1 23.51	+0.04	-1 23.47	.....	0.76
6	22	20	2	.....	.....	.....	+1 37.41	+0.10	+1 37.51	.....	0.68

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date—1900	Comp.	No.	Measured	Ref.	Corrected	Measured	Ref.	Corrected	Parallax Factors
90° Time	Star.	Obs.	$\Delta\alpha$		$\Delta\alpha$	$\Delta\delta$		$\Delta\delta$	$\Delta\alpha$ $\Delta\delta$
Nov.13 6 <sup>h</sup> 52 <sup>m</sup> 45 <sup>s</sup>	1	5	.....	.....	.....	-1 28.49	+0.03	-1 28.46	+0.12
6 56 26	2	5	.....	.....	.....	+1 32.87	+0.09	+1 32.96	+0.05
7 4 5	3	5	-3 37.96	-0.11	-3 38.07	.....	.....	.....	-0.549
7 50 51	1	5	-4 13.66	-0.11	-4 13.77	.....	.....	.....	-0.434
7 54 45	2	5	-4 48.51	-0.08	-4 48.59	.....	.....	.....	-0.424
7 59 59	1	5	.....	.....	.....	-1 37.93	+0.02	-1 37.91	-0.91
8 3 21	2	5	.....	.....	.....	+1 23.24	+0.07	+1 23.31	-0.97
8 8 19	1	5	.....	.....	.....	-2 35.77	-0.06	-2 35.83	-1.44
8 55 8	2	5	.....	.....	.....	-0 9.75	0.00	-0 9.75	-1.49
9 1 21	1	5	+2 1.82	+0.02	+2 1.84	.....	.....	.....	-0.231
9 6 12	2	5	+4 10.53	+0.10	+4 10.63	.....	.....	.....	-0.216
9 12 58	1	5	.....	.....	.....	-2 40.56	-0.05	-2 40.61	-1.61
9 17 50	2	5	.....	.....	.....	-0 13.71	-0.01	-0 13.72	1.64
9 23 16	1	5	+1 44.29	+0.02	+1 44.31	.....	.....	.....	-0.160
9 28 39	2	5	+3 52.80	+0.07	+3 52.87	.....	.....	.....	-0.144
11 24 26	1	5	+0 50.23	+0.01	+0 50.24	.....	.....	.....	+0.225
11 29 51	2	5	+2 16.80	+0.05	+2 16.85	.....	.....	.....	+0.241
11 35 56	1	5	.....	.....	.....	+0 15.44	+0.01	+0 15.45	-1.46
11 40 25	2	5	.....	.....	.....	-0 41.53	0.00	-0 41.53	-1.42
11 45 22	1	5	+0 33.44	+0.01	+0 33.45	.....	.....	.....	+0.290
11 50 13	2	5	+2 0.43	+0.04	+2 0.47	.....	.....	.....	+0.305
11 55 31	1	5	.....	.....	.....	+0 11.02	0.00	+0 11.02	-1.29
11 59 27	2	5	.....	.....	.....	-0 45.92	0.00	-0 45.92	-1.25
15 56 23	3	5	.....	.....	.....	-1 44.56	+0.03	-1 44.53	+3.09
16 2 4	2	5	.....	.....	.....	+1 16.87	-0.02	+1 16.85	+3.21
16 8 34	2	5	-1 14.12	-0.08	-1 14.20	.....	.....	.....	+0.740
16 14 9	3	5	+1 19.05	+0.07	+1 19.12	.....	.....	.....	+0.740
16 20 35	3	5	.....	.....	.....	-1 51.04	+0.01	-1 51.03	+3.65
16 26 36	2	5	.....	.....	.....	+1 10.29	-0.04	+1 10.25	+3.78
16 32 7	2	5	-1 30.65	0.00	-1 30.74	.....	.....	.....	+0.737
16 35 50	3	5	+1 3.68	+0.08	+1 3.76	.....	.....	.....	+0.736
16 54 26	3	5	.....	.....	.....	-1 59.79	0.02	-1 59.81	+4.35
16 58 50	2	5	.....	.....	.....	+1 1.70	-0.08	+1 1.62	+4.52
17 5 49	2	5	-1 54.34	-0.12	-1 54.46	.....	.....	.....	+0.720
17 9 57	3	5	+0 39.74	+0.05	+0 39.79	.....	.....	.....	+0.717
17 15 58	3	5	.....	.....	.....	-2 5.67	-0.05	-2 5.72	+4.90
17 20 1	2	5	.....	.....	.....	+0 55.88	-0.13	+0 55.75	+4.98
17 32 8	2	5	.....	.....	.....	+0 52.99	-0.14	+0 52.85	+5.27
17 36 36	3	5	+0 21.59	+0.01	+0 21.60	.....	.....	.....	+0.690
17 40 36	3	6	+0 18.57	+0.01	+0 18.58	.....	.....	.....	+0.686
17 46 16	2	6	.....	.....	.....	+0 49.20	-0.17	+0 49.03	+5.56
17 53 2	2	6	.....	.....	.....	+0 47.26	-0.18	+0 47.08	+5.69
17 58 15	3	6	+0 6.58	-0.03	+0 6.55	.....	.....	.....	+0.662
18 4 11	3	6	+0 2.74	-0.04	+0 2.70	.....	.....	.....	+0.654
18 8 12	2	5	.....	.....	.....	+0 43.36	-0.22	+0 43.14	+6.01
18 13 5	2	5	.....	.....	.....	+0 41.96	-0.23	+0 41.73	+6.10
18 16 36	3	5	-0 5.73	-0.07	-0 5.80	.....	.....	.....	+0.634
Nov.15 6 13 25	1	5	+0 36.60	0.00	+0 36.60	.....	.....	.....	+0.619
6 17 6	2	5	+1 19.30	+0.06	+1 19.36	.....	.....	.....	-0.612
6 21 36	1	5	.....	.....	.....	1 11.74	-0.03	-1 11.77	+0.49
6 25 19	2	5	.....	.....	.....	+1 6.97	0.00	+1 6.97	+0.41
6 49 14	1	5	.....	.....	.....	1 18.10	-0.02	-1 18.12	0.02
6 53 1	2	5	.....	.....	.....	-1 0.95	0.00	+1 0.95	-0.07
6 56 56	1	5	+0 4.03	-0.02	+0 4.01	.....	.....	.....	-0.534
7 0 18	2	5	+0 47.27	+0.03	+0 47.30	.....	.....	.....	-0.525
7 4 42	1	5	.....	.....	.....	-1 21.56	-0.02	-1 21.58	-0.26
7 8 16	2	5	.....	.....	.....	+0 57.65	+0.01	+0 57.66	-0.33
7 14 27	2	5	.....	.....	.....	-1 29.86	-0.02	-1 29.88	-0.73
7 40 54	1	5	.....	.....	.....	+0 48.63	+0.01	+0 48.64	-0.85
7 44 27	2	5	.....	.....	.....	.....	.....	.....	-0.412
7 48 32	2	5	+0 11.10	+0.01	+0 11.11	.....	.....	.....	-0.398
7 51 53	1	5	0 36.87	-0.03	0 36.90	.....	.....	.....	.....
7 55 45	2	5	.....	.....	.....	+0 46.07	+0.01	+0 46.08	-0.99
Nov.21 5 33 26	1	4	.....	.....	.....	-0 10.62	-0.02	-0 10.64	+0.89
5 36 52	2	5	.....	.....	.....	+0 1.04	+0.03	+0 1.07	+0.82
5 40 34	3	5	.....	.....	.....	+0 56.71	+0.04	+0 56.75	+0.74
5 47 5	1	5	+0 57.24	+0.02	+0 57.26	.....	.....	.....	-0.592
5 51 5	2	5	-1 39.41	-0.05	-1 39.46	.....	.....	.....	-0.585
5 54 44	3	5	-1 25.62	-0.02	-1 25.64	.....	.....	.....	-0.578
6 0 16	1	5	.....	.....	.....	-0 22.70	0.02	-0 22.72	+0.39

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\delta$
Nov. 21	6 <sup>h</sup> 4 <sup>m</sup> 25 <sup>s</sup>	2	6	.....	.....	.....	-0' 11.86	+0.03	-0' 11.83	.....
	6 8 4 3	5	.....	.....	.....	+0 44.09	+0.04	+0 44.13	.....	+0.52
	6 12 56 4	5	.....	.....	.....	+0 39.93	+0.08	+0 40.01	.....	+0.25
	6 17 56 4	4	-4' 30.89	-0.10	-4' 30.99	.....	.....	.....	-0.552	+0.16
	6 24 0 4	4	-4 34.41	-0.10	-4 34.51	.....	.....	.....	-0.519	.....
	6 29 44 4	4	.....	.....	.....	+0 32.25	+0.07	+0 32.32	.....	-0.12
	7 11 56 1	5	.....	.....	.....	-0 56.04	-0.02	-0 56.06	.....	-0.72
	7 17 8 2	5	.....	.....	.....	-0 45.73	+0.01	-0 45.72	.....	-0.78
	7 21 30 3	5	.....	.....	.....	+0 9.88	+0.03	+0 9.91	.....	-0.83
	7 27 7 1	5	-0 3.97	-0.01	-0 3.98	.....	.....	.....	-0.365	.....
	7 31 54 2	5	-2 40.92	-0.07	-2 40.99	.....	.....	.....	-0.354	.....
	7 36 29 3	5	-2 27.47	-0.05	-2 27.52	.....	.....	.....	-0.340	.....
	7 42 50 1	5	.....	.....	.....	-1 10.96	-0.02	-1 10.98	.....	-1.07
	7 47 56 2	5	.....	.....	.....	1 0.35	0.00	1 0.35	.....	-1.12
	7 52 25 3	5	.....	.....	.....	0 5.22	+0.02	0 5.20	.....	-1.16
	8 14 13 1	5	.....	.....	.....	-1 26.16	-0.01	-1 26.17	.....	-1.34
	8 20 8 2	5	.....	.....	.....	-1 15.90	0.00	-1 15.90	.....	-1.39
	8 25 27 3	5	.....	.....	.....	-0 21.13	+0.02	-0 21.11	.....	-1.42
	16 46 13 1	5	.....	.....	.....	-1 21.79	+0.12	-1 21.67	.....	+5.32
	16 54 40 1	5	+2 8.48	+0.14	+2 8.62	.....	.....	.....	+0.666	.....
	17 6 45 1	7	.....	.....	.....	-1 33.81	+0.09	-1 33.72	.....	+5.72
	17 15 42 1	6	+1 56.03	+0.12	+1 56.15	.....	.....	.....	+0.639	.....
	17 26 21 1	5	.....	.....	.....	-1 45.32	+0.07	-1 45.25	.....	+6.14
	17 33 30 1	5	+1 47.91	+0.10	+1 48.01	.....	.....	.....	+0.616	.....
Nov. 22	7 25 16 1	6	.....	.....	.....	-1 24.15	-0.01	-1 24.16	.....	-0.92
	7 30 39 2	5	.....	.....	.....	2 28.56	-0.04	2 28.60	.....	-0.99
	7 37 13 1	5	-1 27.74	-0.04	-1 27.78	.....	.....	.....	-0.320	.....
	7 42 39 2	5	-0 30.39	-0.03	-0 30.42	.....	.....	.....	-0.303	.....
	7 49 39 1	6	.....	.....	.....	1 36.88	-0.02	1 36.90	.....	-1.17
	7 55 21 2	5	.....	.....	.....	-2 41.21	-0.04	-2 41.25	.....	-1.22
	8 22 39 1	5	.....	.....	.....	-1 54.38	-0.03	-1 54.41	.....	-1.41
	8 27 40 2	5	.....	.....	.....	-2 58.30	-0.05	-2 58.35	.....	-1.44
	8 34 11 1	5	-2 1.77	-0.04	-2 1.81	.....	.....	.....	-0.152	.....
	8 38 52 2	5	-1 3.61	-0.03	-1 3.64	.....	.....	.....	-0.140	.....
	8 46 5 1	6	.....	.....	.....	-2 6.98	-0.03	-2 7.01	.....	-1.52
	8 51 50 2	6	.....	.....	.....	-3 11.29	-0.05	-3 11.34	.....	-1.55
	15 52 45 1	5	.....	.....	.....	+4 22.36	+0.24	+4 22.60	.....	+4.25
	15 54 30 2	5	.....	.....	.....	+3 39.93	+0.10	+3 40.03	.....	+4.27
	16 5 12 1	5	+1 27.16	+0.07	+1 27.23	.....	.....	.....	+0.701	.....
	16 9 56 2	5	-0 36.12	-0.05	-0 36.17	.....	.....	.....	+0.701	.....
	16 16 38 1	5	.....	.....	.....	+4 7.54	+0.27	+4 7.81	.....	+4.79
	16 23 21 2	5	.....	.....	.....	+3 24.62	+0.11	+3 24.73	.....	+4.92
	16 29 9 2	5	-0 45.75	-0.04	-0 45.79	.....	.....	.....	+0.687	.....
	16 32 56 1	5	+1 13.62	+0.10	+1 13.72	.....	.....	.....	+0.683	.....
	16 37 55 1	5	+1 11.32	+0.11	+1 11.43	.....	.....	.....	+0.678	.....
	16 44 19 1	5	.....	.....	.....	+3 50.33	+0.32	+3 50.65	.....	+5.39
	16 49 19 2	5	.....	.....	.....	+3 8.58	+0.12	+3 8.70	.....	+5.48
	16 59 6 1	5	+1 1.25	+0.14	+1 1.39	.....	.....	.....	+0.654	.....
	17 6 1 2	5	-1 3.39	-0.02	-1 3.41	.....	.....	.....	+0.646	.....
	17 14 22 1	5	.....	.....	.....	+3 31.66	+0.40	+3 32.06	.....	+5.99
	17 19 35 2	5	.....	.....	.....	+2 49.90	+0.14	+2 50.04	.....	+6.11
	17 26 17 1	6	+0 47.97	+0.18	+0 48.15	.....	.....	.....	+0.618	.....
Nov. 23	9 15 17	5	.....	.....	.....	-2 6.86	-0.04	-2 6.90	.....	-1.51
	9 52 12	5	+0 9.29	+0.01	+0 9.30	.....	.....	.....	+0.108	.....
	9 57 3	5	+0 6.63	+0.01	+0 6.64	.....	.....	.....	+0.124	.....
	10 2 34	5	.....	.....	.....	-2 17.25	-0.04	-2 17.29	.....	-1.46
Nov. 25	6 33 28	1	5	.....	.....	-0 18.04	+0.04	-0 18.00	.....	-0.35
	6 37 21	2	5	.....	.....	+0 49.62	-0.03	+0 49.59	.....	-0.41
	6 42 59	1	5	-4 18.69	-0.10	-4 18.79	.....	.....	-0.413	.....
	6 47 10	2	5	+4 21.93	+0.10	+4 22.03	.....	.....	-0.403	.....
	6 53 34	1	4	-4 24.18	-0.09	-4 24.27	.....	.....	-0.388	.....
	6 57 1	2	4	+4 17.39	+0.09	+4 17.48	.....	.....	-0.378	.....
	7 1 26	1	5	.....	.....	-0 35.04	+0.03	-0 35.01	.....	-0.71
	7 5 9	2	5	+4 21.93	+0.10	+4 22.03	.....	.....	-0.403	.....
	7 45 57	1	5	.....	.....	-1 2.10	+0.01	-1 2.09	.....	-1.15
	7 50 15	2	5	.....	.....	+0 4.55	-0.02	+0 4.53	.....	-1.18
	7 56 55	1	5	-4 45.26	-0.09	-4 45.35	.....	.....	-0.211	.....
	8 1 21	2	5	+3 46.15	+0.07	+3 46.22	.....	.....	-0.199	.....

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date—1900 30 Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Nov. 25 8 <sup>h</sup> 7 <sup>m</sup> 5	1	5	.....	.....	.....	-1' 16.08	0.00	-1' 16.08	..... -1.29
8 11 47	2	5	.....	.....	.....	-0 9.07	-0.02	-0 9.09	..... -1.32
8 42 22	1	5	.....	.....	.....	-1 38.46	-0.02	-1 38.48	..... -1.44
8 47 1	2	5	.....	.....	.....	-0 31.72	-0.01	-0 31.73	..... -1.45
8 54 18	1	5	-5' 22.89	-0.09	-5' 22.98	.....	.....	.....	..... -0.040
8 59 39	2	5	+3 18.80	+0.06	+3 18.86	.....	.....	.....	..... -0.022
9 6 42	1	6	.....	.....	.....	-1 53.95	-0.03	-1 53.98	..... -1.47
9 12 35	2	6	.....	.....	.....	-0 48.34	-0.01	-0 48.35	..... -1.46
15 18 53	2	5	.....	.....	.....	-5 4.57	-0.16	-5 4.73	..... +3.96
15 25 27	3	5	.....	.....	.....	+4 25.55	+0.26	+4 25.81	..... +4.09
15 32 57	2	5	-0 21.58	-0.02	-0 21.60	.....	.....	.....	..... +0.698
15 39 22	3	5	+2 19.25	+0.10	+2 19.35	.....	.....	.....	..... +0.695
15 49 14	2	5	.....	.....	.....	-5 26.68	-0.27	-5 26.95	..... +4.62
15 54 47	3	5	.....	.....	.....	+4 4.20	+0.34	+4 4.54	..... +4.75
16 10 52	2	5	.....	.....	.....	-5 42.33	-0.31	-5 42.64	..... +5.07
16 16 57	3	5	.....	.....	.....	+3 47.94	+0.39	+3 48.33	..... +5.22
16 26 6	3	5	+2 2.55	+0.19	+2 2.74	.....	.....	.....	..... +0.660
16 31 23	4	5	+1 34.02	+0.18	+1 34.20	.....	.....	.....	..... +0.654
16 38 32	3	5	.....	.....	.....	+3 31.86	+0.45	+3 32.31	..... +5.64
16 43 30	4	5	.....	.....	.....	+4 24.34	+0.50	+4 24.84	..... +5.77
16 50 17	3	5	+1 53.96	+0.24	+1 54.20	.....	.....	.....	..... +0.629
16 55 15	4	5	+1 25.36	+0.24	+1 25.60	.....	.....	.....	..... +0.624
17 3 30	3	5	.....	.....	.....	+3 14.11	+0.55	+3 14.66	..... +6.16
17 8 50	4	5	.....	.....	.....	+4 6.21	+0.62	+4 6.83	..... +6.28
17 22 2	3	5	+1 42.37	+0.30	+1 42.67	.....	.....	.....	..... +0.581
17 26 36	4	5	+1 14.21	+0.32	+1 14.53	.....	.....	.....	..... +0.574
17 33 35	3	5	.....	.....	.....	+2 52.50	+0.71	+2 53.21	..... +6.72
17 39 37	4	6	.....	.....	.....	+3 43.99	+0.76	+3 44.75	..... +6.83
17 51 46	3	5	.....	.....	.....	+2 39.20	+0.83	+2 40.03	..... +7.03
17 58 32	3	5	+1 29.78	+0.38	+1 30.16	.....	.....	.....	..... +0.512
Nov. 26 5 35 54	4	5	.....	.....	.....	-3 58.36	-0.04	-3 58.40	..... +0.50
5 42 22	1	5	.....	.....	.....	+5 3.05	+0.11	+5 3.16	..... +0.40
5 48 21	4	5	-2 58.77	-0.15	-2 58.92	.....	.....	.....	..... -0.526
5 52 28	3	5	-2 34.21	-0.13	-2 34.34	.....	.....	.....	..... -0.518
5 56 49	1	5	-2 27.31	+0.01	-2 27.30	.....	.....	.....	..... -0.510
6 2 52	3	5	.....	.....	.....	-5 11.28	-0.05	-5 11.33	..... +0.05
6 7 5	4	5	.....	.....	.....	-4 18.02	-0.04	-4 18.06	..... -0.01
6 11 9	1	5	.....	.....	.....	+4 44.70	+0.11	+4 44.81	..... -0.08
6 19 51	3	5	-2 46.02	-0.13	-2 46.15	.....	.....	.....	..... -0.457
6 24 30	4	5	-3 14.37	-0.13	-3 14.50	.....	.....	.....	..... -0.448
6 28 50	1	5	-2 40.60	0.00	-2 40.60	.....	.....	.....	..... -0.438
7 13 46	1	5	.....	.....	.....	+4 4.56	+0.09	+4 4.65	..... -0.88
7 19 3	4	5	.....	.....	.....	-4 35.76	-0.05	-4 35.81	..... -0.93
7 25 19	4	5	-3 41.38	-0.11	-3 41.49	.....	.....	.....	..... -0.290
7 30 16	1	5	-3 7.49	-0.03	-3 7.52	.....	.....	.....	..... -0.276
7 37 25	4	5	.....	.....	.....	-4 23.76	-0.06	-4 23.82	..... -1.10
7 42 47	1	5	.....	.....	.....	+3 45.67	+0.08	+3 45.75	..... -1.13
8 9 17	1	5	.....	.....	.....	+3 27.98	+0.07	+3 28.05	..... -1.30
8 15 45	1	5	-3 27.90	-0.05	-3 27.95	.....	.....	.....	..... -0.142
12 14 41	2	6	.....	.....	.....	+2 48.59	0.00	+2 48.59	..... +0.25
12 22 16	2	6	-2 59.29	+0.12	-2 59.41	.....	.....	.....	..... +0.536
12 31 8	2	5	.....	.....	.....	+2 36.53	0.00	+2 36.53	..... +0.53
12 37 20	1	5	.....	.....	.....	+0 18.54	-0.09	+0 18.45	..... +0.64
12 44 0	1	5	-5 25.74	-0.15	-5 25.89	.....	.....	.....	..... +0.577
12 51 57	1	5	.....	.....	.....	+0 7.92	-0.10	+0 7.82	..... +0.92
12 59 14	2	5	.....	.....	.....	+2 15.39	+0.02	+2 15.41	..... +1.05
15 15 2	2	5	-4 5.72	-0.22	-4 5.94	.....	.....	.....	..... +0.699
15 21 43	5	5	+4 36.42	+0.22	+4 36.64	.....	.....	.....	..... +0.697
15 27 23	6	5	+0 1.09	+0.01	+0 1.10	.....	.....	.....	..... -0.695
15 33 39	2	5	.....	.....	.....	+0 19.35	-0.26	+0 19.09	..... +4.36
15 39 29	5	5	.....	.....	.....	-0 56.36	+0.21	-0 56.15	..... +4.50
15 44 26	6	5	.....	.....	.....	+1 4.03	+0.04	+1 4.07	..... +4.61
16 0 38	2	6	.....	.....	.....	-0 1.24	-0.29	-0 1.53	..... +4.96
16 10 16	5	5	+3 39.90	+0.25	+3 40.15	.....	.....	.....	..... +0.669
16 15 26	6	5	-0 15.06	+0.01	-0 15.05	.....	.....	.....	..... +0.664
16 20 51	2	5	-4 28.56	-0.33	-4 28.89	.....	.....	.....	..... +0.660
16 29 49	5	5	.....	.....	.....	-1 34.85	+0.25	-1 34.60	..... +5.57
16 33 57	6	5	.....	.....	.....	+0 25.91	0.00	+0 25.91	..... +5.67
16 38 10	2	5	.....	.....	.....	-0 29.88	-0.44	-0 30.32	..... +5.76
16 49 26	2	5	4 37.09	-0.38	4 37.47	.....	.....	.....	..... +0.625

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date—1900	Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	$\Delta\delta$
Nov. 26 16	58 <sup>m</sup> 13 <sup>s</sup>	2	5	.....	.....	.....	-0° 44' 30	-0° 60	-0° 44' 30	.....	+6' 20
Nov. 27	5 21 40	7.7	5	.....	.....	.....	-2 52.55	-0.11	-2 52.66	.....	+0.72
	5 25 4	1	5	.....	.....	.....	-0 18.12	-0.01	-0 18.13	.....	+0.65
	5 30 14	7.7	5	+3' 37.30	+0.05	+3' 37.35	.....	.....	.....	-0.548	.....
	5 34 31	1	5	+0 20.79	0.00	+0 20.79	.....	.....	.....	-0.540	.....
	5 39 29	7.7	5	.....	.....	.....	-3 3.92	-0.11	-3 4.03	.....	+0.40
	5 43 9	1	5	.....	.....	.....	-0 30.04	-0.01	-0 30.05	.....	+0.34
	5 54 32	7.7	5	+3 28.04	+0.03	+3 28.07	.....	.....	.....	-0.494	.....
	5 59 15	1	5	+0 11.06	-0.01	+0 11.05	.....	.....	.....	-0.489	.....
	6 4 11	2	5	-2 8.83	-0.03	-2 8.86	.....	.....	.....	-0.479	.....
	6 8 22	2	5	.....	.....	.....	+1 44.96	+0.06	+1 45.02	.....	-0.06
	6 12 45	2	5	-2 12.08	-0.03	-2 12.11	.....	.....	.....	-0.461	.....
	6 40 28	7.7	5	.....	.....	.....	-3 44.71	-0.09	-3 44.80	.....	-0.50
	6 44 53	1	5	.....	.....	.....	-1 11.17	-0.02	-1 11.19	.....	-0.55
	6 48 46	2	5	.....	.....	.....	+1 17.75	+0.04	+1 17.79	.....	-0.60
	6 53 34	7.7	5	+3 3.92	+0.02	+3 3.94	.....	.....	.....	-0.361	.....
	6 57 42	1	5	-0 12.00	-0.02	-0 12.02	.....	.....	.....	-0.350	.....
	7 1 41	2	5	-2 31.58	-0.04	-2 31.62	.....	.....	.....	-0.340	.....
	7 6 12	7.7	5	.....	.....	.....	-4 1.92	-0.09	-4 2.01	.....	-0.80
	7 9 54	1	5	.....	.....	.....	-1 28.19	-0.02	-1 28.21	.....	-0.83
	7 14 23	2	5	.....	.....	.....	+1 0.42	+0.03	+1 0.45	.....	-0.88
	7 14 51	7.7	5	.....	.....	.....	-4 28.52	-0.09	-4 28.61	.....	-1.13
	7 49 56	1	5	.....	.....	.....	-1 55.71	-0.03	-1 55.74	.....	-1.17
	7 53 54	2	4	.....	.....	.....	+0 33.29	+0.02	+0 33.31	.....	-1.20
	7 59 45	7.7	5	+2 37.21	+0.03	+2 37.24	.....	.....	.....	-0.177	.....
	8 4 10	1	4	-0 39.21	-0.02	-0 39.23	.....	.....	.....	-0.162	.....
	8 7 48	2	4	-2 85.59	-0.05	-2 58.64	.....	.....	.....	-0.153	.....
	8 13 21	7.7	5	.....	.....	.....	-4 48.33	-0.09	-4 48.42	.....	-1.29
Nov. 29	5 31 41	1	5	.....	.....	.....	-0 39.40	+0.01	-0 39.39	.....	+0.43
	5 35 1	2	5	.....	.....	.....	+1 21.53	+0.06	+1 21.59	.....	+0.37
	5 38 29	3	5	.....	.....	.....	-0 55.50	-0.05	-0 55.55	.....	+0.32
	5 43 22	1	5	-1 16.01	-0.04	-1 16.05	.....	.....	.....	-0.496	.....
	5 48 23	2	5	-2 17.44	-0.04	-2 17.48	.....	.....	.....	-0.486	.....
	5 52 0	3	5	+2 29.69	+0.05	+2 29.74	.....	.....	.....	-0.478	.....
	5 57 15	1	5	.....	.....	.....	-0 57.81	0.00	-0 57.81	.....	+0.02
	6 1 31	2	5	.....	.....	.....	+1 2.33	+0.05	+1 2.38	.....	-0.04
	6 5 55	3	5	.....	.....	.....	-1 15.33	-0.05	-1 15.38	.....	-0.10
	6 11 31	1	5	-1 25.18	-0.04	-1 25.22	.....	.....	.....	-0.435	.....
	6 15 35	2	5	-2 26.43	-0.04	-2 26.47	.....	.....	.....	-0.426	.....
	6 19 0	3	5	+2 21.49	+0.03	+2 21.52	.....	.....	.....	-0.416	.....
	6 23 24	1	5	.....	.....	.....	-1 16.65	-0.01	-1 16.66	.....	-0.35
	6 27 7	2	5	.....	.....	.....	+0 43.80	+0.04	+0 43.84	.....	-0.40
	6 30 25	3	5	.....	.....	.....	-1 33.14	-0.05	-1 33.19	.....	-0.43
	7 14 11	1	5	.....	.....	.....	-1 53.82	-0.02	-1 53.84	.....	-0.90
	7 20 59	2	5	.....	.....	.....	-0 4.17	+0.01	-0 4.16	.....	-0.95
	7 26 31	3	5	.....	.....	.....	-2 13.99	-0.05	-2 14.04	.....	-0.99
	7 32 49	1	5	-1 50.91	-0.05	-1 50.96	.....	.....	.....	-0.224	.....
	7 39 36	2	5	-2 53.15	-0.05	-2 53.20	.....	.....	.....	-0.199	.....
	7 45 20	3	5	+1 53.29	+0.02	+1 53.31	.....	.....	.....	-0.182	.....
	7 52 34	1	5	.....	.....	.....	-2 22.45	-0.04	-2 22.49	.....	-1.17
	7 58 21	2	5	.....	.....	.....	-0 23.47	0.00	-0 23.47	.....	-1.20
	8 5 16	3	5	.....	.....	.....	-2 43.00	-0.05	-2 43.05	.....	-1.23
	8 23 58	1	2	.....	.....	.....	-2 46.09	-0.05	-2 46.14	.....	-1.29
	8 31 16	1	2	.....	.....	.....	-2 51.73	-0.05	-2 51.78	.....	-1.30
	15 42 44	11	5	.....	.....	.....	-0 37.96	-0.01	-0 37.97	.....	+4.95
	15 47 49	11	5	+0 14.75	+0.01	+0 14.76	.....	.....	.....	+0.663	.....
	15 55 25	11	7	.....	.....	.....	-0 48.51	-0.03	-0 48.54	.....	+5.20
	16 1 36	11	8	+0 11.70	0.00	+0 11.70	.....	.....	.....	+0.650	.....
	16 14 37	11	8	.....	.....	.....	-1 4.50	-0.06	-1 4.56	.....	+5.62
	16 20 23	11	7	.....	.....	.....	-1 18.14	-0.11	-1 18.25	.....	+5.94
	16 28 15	11	6	+0 5.03	-0.04	+0 4.99	.....	.....	.....	+0.607	.....
	16 41 58	11	5	.....	.....	.....	-1 29.69	-0.14	-1 29.83	.....	+6.20
Dec. 1	15 30 3	1	5	.....	.....	.....	-1 38.85	+0.01	-1 38.84	.....	+4.91
	15 35 5	2	5	.....	.....	.....	+0 17.10	-0.11	+0 16.99	.....	+5.02
	15 41 42	1	5	+0 56.85	+0.05	+0 56.90	.....	.....	.....	+0.649	.....
	15 48 5	2	6	-1 43.81	-0.14	-1 43.95	.....	.....	.....	+0.644	.....
	16 4 36	2	9	.....	.....	.....	-0 8.90	-0.21	-0 9.11	.....	+5.64
	16 19 14	1	2	.....	.....	.....	-2 22.77	-0.12	-2 22.89	.....	+5.94

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date—1900 90° Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Dec. 1 16 <sup>h</sup> 26 <sup>m</sup> 24 <sup>s</sup>	2	5	-1' 48.85	-0.19	-1' 49.04	.....	.....	.....	+0.600
Dec. 2 5 42 29	1	5	.....	.....	.....	+0 13.76	0.00	+0 13.76	+0.17
5 47 4	2	5	.....	.....	.....	+1 48.70	+0.03	+1 48.73	+0.12
5 51 21	3	5	.....	.....	.....	-2 6.34	-0.04	-2 6.38	+0.05
5 56 24	2	5	+0 22.91	+0.03	+0 22.94	.....	.....	.....	-0.432
6 2 27	3	5	-0 28.13	-0.03	-0 28.16	.....	.....	.....	-0.418
6 11 43	2	5	.....	.....	.....	+1 28.80	+0.02	+1 28.82	-0.23
6 16 11	3	5	.....	.....	.....	-2 26.03	-0.03	-2 26.06	-0.29
Dec. 5 6 49 20	1	5	.....	.....	.....	+1 44.58	+0.03	+1 44.61	-0.60
6 53 23	2	5	.....	.....	.....	-0 19.00	+0.01	-0 18.99	-0.65
6 57 51	1	5	+0 13.57	+0.01	+0 13.58	.....	.....	.....	-0.239
7 2 8	2	5	-2 20.86	-0.05	-2 20.91	.....	.....	.....	-0.228
7 6 31	1	5	.....	.....	.....	+1 29.81	+0.02	+1 29.83	-0.75
7 10 25	2	5	.....	.....	.....	-0 33.86	0.00	-0 33.86	-0.78
7 28 43	1	5	.....	.....	.....	+1 10.07	+0.02	+1 10.09	-0.88
7 32 22	3	5	.....	.....	.....	-1 14.21	-0.02	-1 14.23	-0.90
7 36 50	2	5	.....	.....	.....	-0 57.23	-0.01	-0 57.24	-0.92
7 42 3	1	5	+0 10.60	+0.01	+0 10.61	.....	.....	.....	-0.118
7 45 43	3	5	+0 13.36	0.00	+0 13.36	.....	.....	.....	-0.106
7 49 55	2	5	-2 24.00	-0.04	-2 24.04	.....	.....	.....	-0.095
7 55 11	1	5	.....	.....	.....	+0 46.70	+0.01	+0 46.71	-0.97
7 59 2	3	5	.....	.....	.....	-1 37.81	-0.03	-1 37.84	-0.98
8 3 35	2	5	.....	.....	.....	-1 21.14	-0.02	-1 21.16	-0.99
8 13 49	1	5	.....	.....	.....	+0 29.95	+0.01	+0 29.96	-1.01
8 18 28	3	5	.....	.....	.....	-1 55.06	-0.03	-1 55.09	-1.01
8 24 33	1	5	+0 7.83	0.00	+0 7.83	.....	.....	.....	+0.006
8 29 41	3	5	+0 10.47	0.00	+0 10.47	.....	.....	.....	+0.020
8 34 54	1	5	.....	.....	.....	+0 11.11	0.00	+0 11.11	-1.01
8 38 51	3	5	.....	.....	.....	-2 13.39	-0.04	-2 13.43	-1.00
9 2 12	1	5	.....	.....	.....	-0 13.61	0.00	-0 13.61	-0.94
9 7 23	3	5	.....	.....	.....	-2 39.58	-0.05	-2 39.63	-0.92
9 13 2	1	5	+0 4.70	0.00	+0 4.70	.....	.....	.....	+0.146
9 17 7	3	5	+0 7.55	+0.01	+0 7.56	.....	.....	.....	+0.157
9 21 59	1	5	.....	.....	.....	0 31.70	-0.01	0 31.71	-0.85
9 25 39	1	5	+0 3.87	0.00	+0 3.87	.....	.....	.....	+0.182
9 29 37	1	5	.....	.....	.....	-0 38.70	-0.01	-0 38.71	-0.80
13 53 12	1	5	.....	.....	.....	-1 10.37	-0.07	-1 10.44	+3.27
13 58 44	1	5	-1 0.78	-0.04	-1 0.82	.....	.....	.....	+0.656
14 3 9	1	5	.....	.....	.....	-1 19.81	-0.08	-1 19.89	+3.50
14 11 25	1	5	.....	.....	.....	-1 28.03	-0.09	-1 28.12	+3.67
14 18 32	1	5	-1 0.33	-0.04	-1 0.37	.....	.....	.....	+0.660
14 24 42	1	5	.....	.....	.....	-1 40.93	-0.11	-1 41.04	+3.95
14 32 0	11	5	.....	.....	.....	-0 15.52	+0.07	-0 15.45	+4.10
14 36 49	1	5	.....	.....	.....	-1 52.73	-0.13	-1 52.86	+4.20
14 41 53	11	5	+1 29.57	+0.10	+1 29.67	.....	.....	.....	+0.657
14 58 32	1	5	-0 58.24	-0.07	-0 58.31	.....	.....	.....	+0.651
15 7 53	1	5	.....	.....	.....	2 23.07	-0.18	-2 23.25	+4.89
Dec. 8 6 23 13	9.8	5	.....	.....	.....	+1 10.17	+0.01	+1 10.18	-0.33
6 27 32	9.8	5	+1 5.79	+0.03	+1 5.82	.....	.....	.....	-0.283
6 31 37	9.8	5	.....	.....	.....	+1 2.46	+0.01	+1 2.47	-0.41
6 52 16	9.8	5	.....	.....	.....	+0 43.25	+0.01	+0 43.26	-0.57
6 57 39	9.8	5	+1 8.17	+0.02	+1 8.19	.....	.....	.....	-0.005
7 2 28	9.8	5	.....	.....	.....	+0 34.02	0.00	+0 34.02	-0.64
7 7 56	9.8	5	+1 8.78	+0.02	+1 8.80	.....	.....	.....	-0.178
7 12 15	9.8	5	.....	.....	.....	+0 24.76	0.00	+0 24.76	-0.70
7 24 9	9.8	5	.....	.....	.....	+0 13.71	0.00	+0 13.71	-0.76
7 28 59	9.8	5	+1 10.15	+0.02	+1 10.17	.....	.....	.....	-0.120
7 33 29	9.8	5	.....	.....	.....	+0 4.81	0.00	+0 4.81	-0.79
7 44 7	9.8	5	.....	.....	.....	-0 5.11	0.00	-0 5.11	-0.82
7 48 54	9.8	5	+1 11.84	+0.02	+1 11.86	.....	.....	.....	-0.064
7 53 10	9.8	5	.....	.....	.....	-0 13.58	-0.01	-0 13.59	-0.84
8 13 42	9.8	5	.....	.....	.....	-0 33.15	-0.01	-0 33.16	-0.86
8 18 11	9.8	5	+1 13.99	+0.02	+1 14.01	.....	.....	.....	+0.017
8 22 12	9.8	5	.....	.....	.....	-0 41.24	-0.01	-0 41.25	-0.86
12 53 18	.....	5	.....	.....	.....	-0 13.34	-0.05	-0 13.39	+2.35
12 58 5	.....	5	-1 39.55	-0.06	-1 39.61	.....	.....	.....	+0.614
13 4 19	.....	5	.....	.....	.....	-0 24.94	-0.06	-0 25.00	+2.57
13 11 4	.....	5	-1 37.81	-0.06	-1 37.87	.....	.....	.....	+0.625

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Hour	Min	Sec	Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	Parallax Factors $\Delta\delta$
Dec. 8	13	17	11		5				-0' 37.75	-0.07	0 37.82		+2.84
	13	23	35		5	-1 35.94	-0.06	-1' 36.00				+0.633	+3.10
	13	29	55		5				-0 50.77	-0.07	-0 50.84		+3.43
	13	46	18		5				-1 7.09	-0.09	-1 7.18		+3.54
	13	50	32	11	5				+2 35.67	+0.10	+2 35.77		+0.645
	13	57	6		5	-1 30.62	-0.07	-1 30.69				+0.646	
	14	1 35		11	5	-0 51.13	-0.03	+0 51.16					+3.90
	14	8 23			5				-1 29.89	-0.12	-1 30.01		+4.00
	14	12 52		11	5				+2 12.96	+0.11	+2 13.07		+4.19
	14	21 40			5				-1 43.36	-0.14	-1 43.50		+0.645
	14	28 4			5	-1 25.49	-0.08	-1 25.57					+4.44
	14	34 8			5				1 56.01	-0.16	1 56.17		+4.74
	14	47 36			5				-2 8.72	-0.18	-2 8.90		+0.636
	14	52 51			5	-1 21.01	-0.11	-1 21.12					+4.97
	14	58 33			5				2 20.72	0.21	2 20.93		
Dec. 9	5	19	26	1	5				-1 8.97	-0.03	-1 9.00		+0.47
	5	21	26	2	5				+2 49.60	+0.04	+2 49.64		+0.40
	5	28	35	3	5				-0 43.08	0.03	-0 43.11		+0.33
	5	32	25	1	5	+0 52.44	+0.01	+0 52.45				-0.405	
	5	36	5	2	5	+0 56.30	+0.05	+0 56.35				-0.397	
	5	39	41	3	5	+2 2.24	+0.04	+2 2.28				-0.388	
	5	45	2	1	5				-1 33.12	-0.03	-1 33.15		+0.12
	5	49	14	2	5				+2 26.49	+0.03	+2 26.52		+0.07
	5	53	27	3	5				-1 6.37	-0.04	-1 6.41		+0.02
	6	12	48	1	5				-1 58.10	-0.04	-1 58.14		-0.17
	6	17	20	2	5				+2 0.90	+0.03	+2 0.93		-0.21
	6	21	18	3	5				-1 31.72	-0.04	-1 31.76		-0.25
	6	26	26	1	5	+0 59.26	0.00	+0 59.26				-0.278	
	6	30	4	2	5	+1 2.77	+0.03	+1 2.80				-0.268	
	6	33	37	3	5	+1 58.96	+0.03	+1 58.99				-0.258	
	6	40	20	1	5				2 24.00	-0.05	2 24.05		-0.43
	6	44	37	2	5				+1 35.15	+0.02	+1 35.17		-0.47
	6	49	13	3	5				1 57.93	-0.04	1 57.97		-0.50
	6	49	18	1	5				2 59.62	-0.05	2 59.67		-0.67
	7	7	23	18	2				+0 58.50	+0.01	+0 58.51		-0.69
	7	7	27	33	3				2 33.88	-0.05	2 33.93		-0.71
	7	7	33	25	1	+1 7.18	+0.01	+1 7.19				-0.098	
	7	7	37	35	2	+1 10.95	+0.02	+1 10.97				-0.086	
	7	7	42	0	3	+2 7.24	+0.03	2 7.27				-0.075	
	7	7	48	4	2				+0 34.87	+0.01	+0 34.88		-0.76
	7	7	52	27	1				-3 31.89	-0.06	-3 31.95		0.77
	7	7	56	50	3				-3 1.82	-0.05	-3 1.87		-0.78
	8	3	10	2	5				+0 20.26	+0.01	+0 20.27		-0.78
	8	8	0	2	5	+1 14.52	+0.02	+1 14.54				-0.003	
	8	12	47	2	5				+0 11.40	0.00	+0 11.40		-0.78
	14	58	35	11.5	5				+3 0.64	+0.24	3 0.88		+5.06
	15	3	27	11.5	5	+1 0.21	+0.12	+1 0.33				+0.634	
	15	11	4	11.5	6				2 47.84	+0.28	2 48.12		+5.30
	15	26	36	11.5	5				+2 32.28	+0.33	+2 32.61		+5.62
	15	31	30	11.5	5	+1 7.21	+0.19	+1 7.40				+0.509	
	15	36	54	11.5	5				2 20.97	+0.37	+2 21.34		+5.81
	15	46	1	11.5	5				2 11.68	+0.41	2 12.09		+5.99
	15	51	28	11.5	4	-1 12.88	+0.26	+1 13.14				+0.578	
Dec. 10	5	21	52	1	5				-1 26.51	+0.03	-1 26.54		+0.12
	5	25	48	2	5				1 55.34	-0.03	1 55.37		+0.37
	5	30	18	1	5	-0 32.92	0.00	-0 32.92				-0.398	
	5	34	20	2	5	-0 36.86	-0.03	-0 36.89				-0.389	
	5	39	22	1	5				+1 10.30	+0.02	+1 10.32		+0.20
	5	43	44	2	5				-2 12.10	-0.03	-2 12.13		+0.14
	5	57	5	1	5				+0 53.25	+0.02	+0 53.27		0.00
	6	1 23	2	1	5				-2 28.23	-0.04	-2 28.27		-0.05
	6	6 16	1		5	-0 16.56	0.00	-0 16.56				-0.316	
	6	11 1	2		5	-0 20.42	-0.03	-0 20.45				-0.304	
	6	15	43	1	5				+0 35.92	+0.01	+0 35.93		-0.20
	6	19	6	2	5				-2 45.40	-0.01	-2 45.44		-0.23
	6	19	1	1	5				+0 3.78	0.00	+0 3.78		-0.48
	6	54	28	1	5	-0 8.92	0.00	-0 8.92				-0.195	
	6	58	52	1	5				-0 5.06	0.00	0 5.06		0.54
	7	1 1	1	1	5				-0 10.57	0.00	0 10.57		-0.57

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date, 1900	Comp.	No.	Measured	Ref.	Corrected	Measured	Ref.	Corrected	Parallax Factors
80 Time	Star	Obs.	$\Delta\alpha$		$\Delta\alpha$	$\Delta\delta$		$\Delta\delta$	$\Delta\alpha$ $\Delta\delta$
Dec.10	7 <sup>h</sup> 8 <sup>m</sup> 11 <sup>s</sup>	1	5	-0' 6".46	0.00	-0' 6".46			-0.156
	7 12 19	1	5	.....	.....	-0' 18".06	0.00	-0' 18".06	-0.61
	7 42 25	1	5	.....	.....	-0' 47.34	-0.01	-0' 47.35	-0.71
	7 47 57	1	5	-0' 0.82	0.00	-0' 0.82			-0.047
	7 52 32	1	5	.....	.....	-0' 57.23	-0.02	-0' 57.25	-0.72
Dec.11	5 2 0	10.5	5	.....	.....	0 11.07	-0.01	0 11.08	+0.72
	5 6 14	10.5	5	+0' 13.45	0.00	+0' 13.45			-0.441
	5 11 34	10.5	5	+0' 14.70	0.00	+0' 14.70			-0.431
	5 15 49	10.5	5	.....	.....	-0' 24.02	-0.01	-0' 24.03	+0.54
	5 29 5	10.5	5	.....	.....	-0' 36.78	-0.01	-0' 36.79	+0.36
	5 33 20	10.5	5	+0' 19.68	0.00	+0' 19.68			-0.384
	5 36 34	10.5	5	+0' 20.43	0.00	+0' 20.43			-0.377
	5 41 28	10.5	5	.....	.....	-0' 48.38	-0.02	-0' 48.40	+0.21
	6 0 35	10.5	5	.....	.....	-1' 6.60	-0.02	-1' 6.62	+0.02
	6 6 11	10.5	5	+0' 26.73	0.00	+0' 26.73			-0.308
	6 10 10	10.5	5	+0' 27.73	0.00	+0' 27.73			-0.298
	6 14 40	10.5	5	.....	.....	-1' 19.98	-0.03	-1' 20.01	-0.15
	6 38 54	10.5	5	.....	.....	-1' 43.11	-0.03	-1' 43.14	-0.35
	6 44 31	10.5	5	+0' 35.26	0.00	+0' 35.26			-0.213
	6 48 23	10.5	5	+0' 36.02	0.00	+0' 36.02			-0.203
	6 54 16	10.5	7	.....	.....	-1' 57.93	-0.04	-1' 57.97	-0.46
	7 15 8	10.5	5	.....	.....	-2' 18.22	-0.04	-2' 18.26	-0.57
	7 21 26	10.5	5	+0' 42.85	+0.01	+0' 42.86			-0.115
	7 26 58	10.5	5	.....	.....	-2' 29.80	-0.04	-2' 29.84	-0.61
	13 51 8	1	5	.....	.....	2' 2.61	-0.14	2' 2.75	+3.83
	13 55 54	2	5	.....	.....	+3' 47.32	+0.05	+3' 47.37	+3.89
	14 2 4	1	5	-1' 46.70	-0.09	-1' 46.79			+0.632
	14 6 42	2	5	-1' 16.56	-0.08	-1' 16.64			+0.631
	14 12 39	1	5	.....	.....	-2' 25.15	-0.19	-2' 25.34	+4.29
	14 16 51	2	5	.....	.....	+3' 25.12	+0.06	+3' 25.18	+4.37
	14 31 37	1	5	.....	.....	-2' 45.18	-0.24	-2' 45.42	+4.62
	14 35 33	2	5	.....	.....	+3' 5.52	+0.07	+3' 5.59	+4.70
	14 41 31	1	5	-1' 34.53	-0.14	-1' 34.67			+0.622
	14 45 39	2	5	-1' 4.16	-0.05	-1' 4.21			+0.621
	14 51 35	1	5	.....	.....	-3' 6.21	-0.28	-3' 6.49	+5.06
	14 55 53	2	5	.....	.....	+2' 44.11	+0.08	+2' 44.79	+5.16
	15 25 7	2	5	.....	.....	+2' 13.57	+0.11	+2' 13.68	+5.75
	15 31 25	2	5	-0' 48.22	+0.01	0' 48.21			+0.584
	15 37 48	2	5	.....	.....	+2' 0.29	+0.12	+2' 0.41	+5.98
Dec.12	4 58 29	1	5	.....	.....	-1' 21.50	-0.01	-1' 21.51	+0.78
	5 3 44	1	5	-1' 35.77	-0.05	-1' 35.82			-0.436
	5 8 56	1	5	.....	.....	-1' 31.67	-0.01	-1' 31.68	+0.63
	5 13 23	2	5	.....	.....	+1' 14.68	+0.04	+1' 14.72	+0.58
	5 17 41	1	5	.....	.....	-1' 39.87	-0.01	-1' 39.88	+0.51
	5 22 45	2	5	-1' 36.55	-0.03	-1' 36.58			-0.394
	5 26 44	1	5	-1' 29.41	-0.05	-1' 29.46			-0.385
	5 31 12	3	5	-0' 6.07	0.00	-0' 6.07			-0.377
	5 35 41	1	5	.....	.....	-1' 56.99	0.03	-1' 57.02	+0.29
	5 39 31	2	5	.....	.....	+0' 49.42	+0.03	+0' 49.45	+0.24
	5 42 51	3	5	.....	.....	+0' 24.98	+0.01	+0' 24.99	+0.20
	5 51 32	1	5	-1' 22.68	-0.04	-1' 22.72			-0.333
	5 54 57	2	5	-1' 27.85	-0.03	-1' 27.88			-0.323
	5 59 56	3	5	+0' 0.81	0.00	+0' 0.81			-0.312
	6 5 48	1	5	.....	.....	-2' 26.07	-0.03	-2' 26.10	-0.03
	6 9 52	2	5	.....	.....	+0' 20.17	+0.02	+0' 20.19	-0.09
	6 13 16	3	5	.....	.....	-0' 4.29	0.00	-0' 4.29	-0.12
	6 40 10	1	5	.....	.....	-2' 59.50	-0.05	-2' 59.55	-0.33
	6 44 55	2	5	.....	.....	-0' 13.66	0.00	-0' 13.66	-0.36
	6 48 58	3	5	.....	.....	-0' 38.77	-0.01	-0' 38.78	-0.39
	6 53 55	1	5	-1' 6.63	-0.03	1' 6.66			-0.175
	6 57 48	2	5	-1' 11.17	-0.02	-1' 11.19			-0.164
	7 1 36	3	5	+0' 17.63	0.00	+0' 17.63			-0.157
	7 7 0	1	5	.....	.....	-3' 26.04	-0.06	-3' 26.10	-0.46
	7 10 59	2	5	.....	.....	-0' 39.52	-0.01	-0' 39.53	-0.50
	7 14 48	3	5	.....	.....	-1' 4.50	-0.02	-1' 4.52	-0.51
	7 30 18	1	5	.....	.....	-3' 48.46	-0.06	-3' 48.52	-0.57
	7 34 57	2	5	.....	.....	-1' 3.31	-0.02	-1' 3.33	-0.58
	7 39 16	3	5	.....	.....	-1' 28.56	-0.03	-1' 28.59	-0.59
	7 44 55	1	5	+0' 53.71	+0.01	+0' 53.72			-0.038

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Time	Comp.	No.	Measured	Ref.	Corrected	Measured	Ref.	Corrected	Parallax	Factors
or Time	Star	Obs.	$\Delta\alpha$			$\Delta\alpha$	$\Delta\delta$		$\Delta\delta$	$\Delta\alpha$	$\Delta\delta$
Dec. 12	7 49 33	2	5	+0' 58.00	+0.02	+0' 58.02	.....	.....	.....	-0.027	.....
	7 53 26	3	5	-0 30.53	-0.01	-0 30.54	.....	.....	.....	-0.017	.....
	8 0 16	1	5	.....	.....	.....	-4 18.54	-0.08	-4 18.62	.....	-0.61
	8 5 26	2	5	.....	.....	.....	-1 33.30	-0.03	-1 33.33	.....	-0.60
	8 9 25	3	5	.....	.....	.....	-1 58.88	-0.03	-1 58.91	.....	-0.60
Dec. 17	8 57 8	1	5	.....	.....	.....	-1 37.72	-0.03	-1 37.75	.....	-0.07
	9 1 4	2	5	.....	.....	.....	-1 58.97	-0.04	-1 59.01	.....	-0.05
	9 7 3	1	5	+0 6.16	+0.01	+0 6.17	.....	.....	.....	+0.214	.....
	9 9 48	2	1	-1 49.98	-0.02	-1 50.00	.....	.....	.....	+0.224	.....
Dec. 18	4 55 15	1	5	.....	.....	.....	-0 30.88	0.00	-0 30.88	.....	+0.91
	4 58 57	2	5	.....	.....	.....	+0 8.28	-0.03	+0 8.25	.....	+0.87
	5 3 4	1	5	-0 29.16	-0.01	-0 29.17	.....	.....	.....	-0.384	.....
	5 7 6	2	5	+2 56.91	+0.06	+2 56.97	.....	.....	.....	-0.373	.....
	5 11 52	1	5	.....	.....	.....	-0 47.78	-0.01	-0 47.79	.....	+0.70
	5 15 48	2	5	.....	.....	.....	-0 8.78	-0.03	-0 8.81	.....	+0.66
	5 20 33	3	5	.....	.....	.....	+0 42.63	+0.01	+0 42.64	.....	+0.60
	5 24 39	1	5	.....	.....	.....	-1 0.68	-0.01	-1 0.69	.....	+0.56
	5 28 28	2	5	.....	.....	.....	-0 21.69	-0.03	-0 21.72	.....	+0.51
	5 32 55	3	5	+0 23.41	+0.01	+0 23.42	.....	.....	.....	-0.320	.....
	5 36 54	2	5	+3 13.67	+0.06	+3 13.73	.....	.....	.....	-0.311	.....
	5 41 5	3	4	.....	.....	.....	+0 21.78	0.00	+0 21.78	.....	+0.39
	5 44 38	1	5	.....	.....	.....	-1 20.83	-0.02	-1 20.85	.....	+0.35
	5 48 38	1	5	0 3.79	0.01	-0 3.80	.....	.....	.....	-0.284	.....
	5 52 59	2	5	.....	.....	.....	-0 46.94	-0.03	-0 46.97	.....	+0.28
	6 35 52	1	5	.....	.....	.....	-2 13.36	-0.04	-2 13.40	.....	-0.03
	6 41 1	2	5	.....	.....	.....	-1 36.15	-0.04	-1 36.19	.....	-0.06
	6 46 31	1	5	+0 27.57	0.00	+0 27.57	.....	.....	.....	-0.142	.....
	6 52 36	2	5	+3 55.09	+0.06	+3 55.15	.....	.....	.....	-0.127	.....
	6 58 57	1	5	.....	.....	.....	-2 37.14	-0.05	-2 37.19	.....	-0.14
	7 3 3	2	5	.....	.....	.....	-1 58.85	-0.04	-1 58.89	.....	-0.15
	7 16 37	1	5	.....	.....	.....	-2 55.60	-0.05	-2 55.65	.....	-0.20
	7 21 13	2	5	.....	.....	.....	-2 17.69	-0.04	-2 17.73	.....	-0.20
	7 26 19	2	5	+4 13.11	+0.07	+4 13.18	.....	.....	.....	-0.039	.....
	7 31 22	1	5	+0 51.95	+0.01	+0 51.96	.....	.....	.....	-0.026	.....
	7 37 26	1	5	.....	.....	.....	-3 17.21	-0.06	-3 17.27	.....	-0.22
	7 41 26	2	5	.....	.....	.....	-2 39.04	-0.05	-2 39.09	.....	-0.22
	12 46 31	9	5	.....	.....	.....	-1 32.15	+0.07	-1 32.08	.....	+3.22
	12 51 37	9	5	+3 23.48	+0.16	+3 23.64	.....	.....	.....	+0.586	.....
	12 57 48	9	5	.....	.....	.....	-1 44.81	+0.08	-1 44.73	.....	+3.43
	13 59 46	9	5	.....	.....	.....	-2 53.55	+0.14	-2 53.41	.....	+3.47
	14 6 28	9	6	+4 11.85	+0.26	+4 12.11	.....	.....	.....	+0.595	.....
	14 12 43	9	5	.....	.....	.....	-3 8.10	+0.15	-3 7.95	.....	+3.72
	14 20 59	12	5	.....	.....	.....	-1 54.84	-0.20	-1 55.04	.....	+3.88
	14 27 28	12	5	0 57.28	-0.13	0 57.11	.....	.....	.....	+0.587	.....
	14 33 15	12	5	.....	.....	.....	-2 8.72	-0.23	-2 8.95	.....	+4.13
	14 45 34	9	5	.....	.....	.....	-3 44.32	+0.18	-3 44.14	.....	+1.37
	14 53 47	9	5	+4 42.91	+0.32	+4 43.23	.....	.....	.....	+0.570	.....
	15 2 4	9	6	.....	.....	.....	-4 2.66	+0.20	-4 2.46	.....	+4.68
Dec. 19	5 6 24	1	5	.....	.....	.....	+0 18.45	0.00	+0 18.45	.....	+0.81
	5 11 0	1	5	+0 16.18	+0.01	+0 16.19	.....	.....	.....	-0.390	.....
	5 14 58	1	5	.....	.....	.....	+0 9.88	0.00	+0 9.88	.....	+0.70
	5 21 0	2	5	.....	.....	.....	-0 26.91	-0.03	-0 26.94	.....	+0.64
	5 27 0	1	6	.....	.....	.....	-0 2.24	0.00	-0 2.24	.....	+0.57
	5 32 26	2	5	+2 42.30	+0.05	+2 42.35	.....	.....	.....	-0.313	.....
	5 36 3	1	5	+0 31.34	+0.01	+0 31.35	.....	.....	.....	-0.307	.....
	5 40 14	2	5	.....	.....	.....	-0 46.47	-0.03	-0 46.50	.....	+0.44
	5 43 54	1	5	.....	.....	.....	-0 19.49	-0.01	-0 19.50	.....	+0.41
	6 0 0	1	5	.....	.....	.....	-0 36.05	-0.01	-0 36.06	.....	+0.26
	6 4 2	1	5	0 48.02	+0.01	+0 48.03	.....	.....	.....	0.242	.....
	6 7 58	1	5	.....	.....	.....	-0 44.23	-0.02	-0 44.25	.....	+0.18
	6 31 8	1	5	.....	.....	.....	-1 8.20	-0.02	-1 8.22	.....	+0.04
	6 36 6	3	5	.....	.....	.....	+2 42.73	+0.04	+2 42.77	.....	+0.02
	6 41 17	1	5	-1 9.92	+0.02	-1 9.94	.....	.....	.....	-0.149	.....
	6 45 14	3	5	-0 45.37	+0.02	-0 45.39	.....	.....	.....	-0.139	.....
	6 49 55	1	5	.....	.....	.....	-1 27.73	-0.03	-1 27.76	.....	-0.05
	6 53 56	3	5	.....	.....	.....	+2 24.10	+0.04	+2 24.14	.....	-0.07
	7 13 15	3	5	.....	.....	.....	+2 4.04	+0.03	+2 4.07	.....	-0.28
	7 18 12	1	5	.....	.....	.....	-1 57.18	-0.04	-1 57.22	.....	-0.29

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date 1900 90 Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Dec.19 7 <sup>h</sup> 23 <sup>m</sup> 38 <sup>s</sup>	3	5	+1' 8.15	+0.02	+1 8.17	.....	.....	.....	-0.042
7 27 54	1	5	+1 37.29	+0.03	+1 37.32	.....	.....	.....	-0.031
7 33 19	3	5	.....	.....	.....	+1 42.73	+0.03	+1 42.76	-0.31
7 37 28	1	5	.....	.....	.....	-2 17.38	-0.04	-2 17.42	-0.31
12 47 48	1	5	.....	.....	.....	+0 36.40	+0.07	+0 36.47	+3.31
12 52 36	2	5	.....	.....	.....	+1 0.58	+0.04	+1 0.62	+3.41
12 57 38	3	5	.....	.....	.....	+0 43.74	+0.01	+0 43.75	+3.53
13 1 44	4	5	.....	.....	.....	+1 16.32	-0.01	+1 16.31	+3.59
13 7 21	1	5	+2 0.54	+0.10	+2 0.64	.....	.....	.....	+0.590
13 12 35	2	5	+0 44.39	+0.04	+0 44.43	.....	.....	.....	+0.592
13 16 38	3	5	-0 7.68	-0.01	-0 7.69	.....	.....	.....	+0.593
13 20 46	4	5	-0 55.94	-0.05	-0 55.99	.....	.....	.....	+0.593
13 26 43	1	5	.....	.....	.....	-0 7.61	+0.11	-0 7.50	+4.07
13 31 25	3	5	.....	.....	.....	+0 5.83	+0.01	+0 5.84	+4.17
13 36 1	2	5	.....	.....	.....	+0 11.77	+0.06	+0 11.83	+4.25
13 39 55	4	5	.....	.....	.....	+0 33.44	-0.02	+0 33.42	+4.32
13 48 7	1	5	+2 28.24	+0.15	+2 28.39	.....	.....	.....	+0.595
13 53 14	2	5	+1 11.91	+0.08	+1 11.99	.....	.....	.....	+0.594
13 57 46	3	5	+0 20.36	+0.02	+0 20.38	.....	.....	.....	+0.593
14 1 52	4	5	-0 27.60	-0.03	-0 27.63	.....	.....	.....	+0.593
14 8 19	3	5	.....	.....	.....	-0 35.44	+0.01	-0 35.43	+4.88
14 12 25	4	5	.....	.....	.....	-0 3.01	-0.03	-0 3.04	+4.97
14 17 58	3	5	+0 34.56	+0.03	+0 34.59	.....	.....	.....	+0.587
14 21 35	4	5	-0 13.40	-0.02	-0 13.42	.....	.....	.....	+0.585
14 25 28	3	5	.....	.....	.....	-0 54.62	0.00	-0 54.62	+5.21
14 29 13	4	5	.....	.....	.....	-0 21.34	-0.03	-0 21.37	+5.29
Dec.20 6 4 37	4	.....	.....	.....	.....	+1 39.11	0.00	+1 39.11	.....
7 35 52	1	-2 12.69	-0.04	-2 12.73	.....	.....	.....	.....	-0.003
Dec.21 13 47 33	1	5	.....	.....	.....	-0 14.22	+0.16	-0 14.06	+4.64
13 53 53	2	5	.....	.....	.....	+0 21.31	+0.21	+0 21.52	+4.75
14 0 10	1	5	+3 8.37	+0.21	+3 8.58	.....	.....	.....	+0.583
14 4 53	2	6	+3 26.01	+0.25	+3 26.26	.....	.....	.....	+0.582
14 11 49	1	5	.....	.....	.....	-0 42.32	+0.20	-0 42.12	+5.09
14 16 40	2	5	.....	.....	.....	-0 5.38	+0.30	-0 5.08	+5.19
Dec.24 13 27 37	1	5	.....	.....	.....	+2 11.15	+0.22	+2 11.37	+4.47
13 31 46	2	5	.....	.....	.....	+3 24.03	+0.21	+3 24.24	+4.55
13 37 50	1	5	+2 34.48	+0.20	+2 34.68	.....	.....	.....	+0.573
13 42 41	2	5	+1 27.12	-0.15	+1 27.27	.....	.....	.....	+0.572
13 47 51	1	5	+2 43.21	+0.23	+2 43.44	.....	.....	.....	+0.571
13 52 16	2	5	+1 35.71	+0.18	+1 35.89	.....	.....	.....	+0.570
13 57 45	1	6	.....	.....	.....	-1 36.94	+0.32	+1 37.26	+5.03
14 5 31	2	7	.....	.....	.....	+2 45.83	+0.34	+2 46.17	+5.17
Dec.26 5 57 36	13	5	.....	.....	.....	-3 33.17	-0.06	-3 33.23	+0.59
6 3 24	13	5	-0 37.46	-0.02	-0 37.48	.....	.....	.....	-0.197
6 10 42	13	5	.....	.....	.....	-3 46.84	-0.06	-3 46.90	+0.51
6 31 35	13	5	.....	.....	.....	-4 9.51	-0.07	-4 9.58	+0.40
6 39 29	13	5	-0 5.20	-0.01	0 5.21	.....	.....	.....	-0.111
6 46 34	13	5	.....	.....	.....	-4 25.08	-0.08	-4 25.16	+0.35
Dec.28 5 20 32	1	5	.....	.....	.....	+4 40.66	+0.09	+4 40.75	+1.00
5 25 20	2	5	.....	.....	.....	-0 4.13	-0.01	-0 4.14	+0.94
5 32 46	1	5	-1 1.09	0.00	-1 1.09	.....	.....	.....	-0.255
5 36 53	2	5	+1 16.36	+0.02	+1 16.38	.....	.....	.....	-0.246
5 43 18	1	5	.....	.....	.....	+4 17.02	+0.08	+4 17.10	+0.81
5 47 50	2	5	.....	.....	.....	-0 27.78	-0.01	-0 27.79	+0.78
6 18 12	1	5	.....	.....	.....	+3 40.23	+0.06	+3 40.29	+0.60
6 23 13	2	5	.....	.....	.....	-1 5.14	-0.02	-1 5.16	+0.57
6 29 31	1	5	-0 4.95	+0.01	-0 4.94	.....	.....	.....	-0.118
6 34 19	2	5	+2 13.70	+0.04	+2 13.74	.....	.....	.....	-0.114
6 41 17	1	5	.....	.....	.....	+3 15.78	+0.06	+3 15.84	+0.50
6 45 22	2	5	.....	.....	.....	-1 28.55	-0.03	-1 28.58	+0.49
7 2 19	1	5	.....	.....	.....	+2 53.32	+0.05	+2 53.37	+0.45
7 7 58	1	5	+0 33.59	+0.01	+0 33.60	.....	.....	.....	-0.032
7 12 56	1	5	.....	.....	.....	+2 41.61	+0.05	+2 41.66	+0.44
11 14 51	8	5	.....	.....	.....	+2 18.81	+0.11	+2 18.92	+2.43
11 21 7	8	5	+3 36.20	+0.10	+3 36.30	.....	.....	.....	+0.487
11 28 30	8	5	.....	.....	.....	+2 3.59	+0.12	+2 3.71	+2.63

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Hour	Min	Sec	Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax $\Delta\alpha$	Factors $\Delta\delta$
Dec. 28	11	45	17	13	5				0 53.98	-0.01	0 53.99		+2.91
	11	50	52	13	5	-0' 10.09	-0.01	-0' 10.10	-0 17.16	-0.01	-0 17.17	+0.509	+3.07
	11	55	11	13	5				+1 18.71	+0.16	+1 18.87		+3.29
	12	7	43	8	5				-0 35.95	-0.01	-0 35.96		+3.36
	12	12	3	13	5							+0.541	
	12	18	2	8	5	+4 35.78	+0.19	+4 35.97				+0.544	
	12	23	17	13	5	+0 24.30	+0.02	+0 24.32					
	12	28	12	8	5				+0 55.78	+0.18	+0 55.96		+3.66
	12	33	9	13	5				-1 0.64	-0.01	-1 0.65		+3.73
Dec. 29	5	26	24	9.5	5				+4 37.13	+0.07	+4 37.20		+1.01
	5	31	51	9.5	5	+2 32.12	+0.06	+2 32.18				-0.250	+0.90
	5	38	40	9.5	5				+4 24.19	+0.07	+4 24.26		+0.77
	5	56	40	1	5				+1 26.60	+0.03	+1 26.63		+0.75
	6	1	11	2	5				-0 22.88	0.00	-0 22.88		-0.174
	6	6	26	1	5	+0 6.46	0.00	+0 6.46				-0.162	
	6	11	1	2	6	-1 25.81	-0.02	-1 25.83					+0.67
	6	17	11	1	5				+1 4.82	+0.01	+1 4.83		+0.65
	6	21	6	2	5				-0 44.09	-0.01	-0 44.10		+0.58
	6	39	51	9.5	5				+3 19.55	+0.05	+3 19.60	-0.080	
	6	46	23	9.5	5	+3 48.94	+0.07	+3 49.01					+0.54
	6	53	28	9.5	5				+3 4.75	+0.05	+3 4.80		+0.52
	7	6	14	9.5	5				+2 50.31	+0.05	+2 50.36	-0.014	
	7	12	43	9.5	5	+4 16.28	+0.07	+4 16.35					+0.52
	7	19	11	9.5	5				+2 37.11	+0.04	+2 37.15		
Dec. 30	5	29	15	1	5				-3 10.94	-0.06	-3 11.00		+1.05
	5	34	24	2	5				-0 54.51	-0.04	-0 55.55		+1.00
	5	39	43	1	5	+0 44.26	0.00	+0 44.26				-0.229	
	5	44	1	2	5	+4 4.26	+0.07	+4 4.33				-0.218	
	5	50	20	1	5				-3 33.28	-0.07	-3 33.35		+0.88
	5	54	25	2	5				-1 15.83	-0.04	-1 15.87		+0.86
	6	43	8	1	3				-4 29.76	-0.08	-4 29.84		+0.63
Dec. 31	5	45	18	9.5	5				+4 21.94	+0.08	+4 22.02		+0.94
	5	53	21	9.5	5	-0 52.13	0.00	-0 52.13				-0.196	
	6	0	9	9.5	5				+4 6.15	+0.07	+4 6.22		+0.84
	6	38	29	9.5	5				+3 25.44	+0.06	+3 25.50		+0.68
	6	45	1	9.5	5	+0 6.34	+0.01	+0 6.35				0.074	
	6	51	25	9.5	5				+3 11.80	+0.05	+3 11.85		+0.65
	7	7	2	59	9.5				+2 59.40	+0.05	+2 59.45		+0.12
	7	8	57	9.5	5	+0 34.43	+0.01	+0 34.44				-0.017	
	7	15	4	9.5	5				+2 46.47	+0.05	+2 46.52		+0.12
	8	57	31	9.5	5				+0 54.96	+0.03	+0 54.99		+1.01
	9	3	43	9.5	5	+2 41.56	+0.05	+2 41.61				+0.248	
	9	10	22	9.5	5				+0 40.82	+0.03	+0 40.85		+1.11
	9	20	7	9.5	5				+0 19.10	+0.03	+0 19.13		+1.30
	9	38	19	9.5	5	+3 20.53	+0.07	+3 20.60				+0.322	
	9	45	0	9.5	6				+0 2.54	+0.03	+0 2.57		+1.45
	10	36	14	9.5	5				-0 54.61	+0.04	-0 54.57		+2.06
	10	43	9	9.5	5	+1 35.33	+0.13	+1 35.46				+0.435	
	10	49	30	9.5	5				-1 9.67	+0.05	-1 9.62		+2.25
	12	43	59	12.5	5				+2 59.74	+0.10	+2 59.84		+4.10
	12	51	4	12.5	5	+0 12.07	+0.03	+0 12.10				+0.549	
	12	57	10	12.5	5				+2 45.05	+0.12	+2 45.17		+4.33
1901 Jan. 1	5	42	41	1	5				-1 38.51	-0.02	-1 38.53		+1.01
	5	48	8	1	5	2 39.81	0.05	-2 39.86				-0.201	
	5	54	11	1	5				-1 50.63	-0.02	-1 50.65		+0.93
	5	59	53	2	5				-4 22.32	-0.08	-4 22.40		+0.91
	6	5	20	2	5	+1 5.90	+0.08	+1 5.82				-0.163	
	6	11	50	2	5				-4 34.99	+0.08	-4 35.07		+0.85
	6	55	15	1	5				-2 55.91	-0.05	-2 55.96		+0.71
	7	0	44	1	5	-1 15.56	+0.02	-1 15.58				-0.034	
	7	7	20	1	5				-3 8.27	-0.05	-3 8.32		+0.70
	10	58	49	1	5				+0 55.77	+0.06	+0 55.86		+2.46
	11	4	0	2	5				+0 58.46	+0.06	+0 58.52		+2.54
	11	11	29	1	5	+1 14.07	+0.13	+1 14.20				+0.472	
	11	15	37	2	5	+2 33.31	+0.10	+2 33.41				+0.477	
	11	21	36	1	5				+0 30.22	+0.10	+0 30.32		+2.81
	11	24	55	2	5				+0 34.38	+0.07	+0 34.45		+2.87

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date, 1900 30 Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Jan. 1 12 <sup>h</sup> 43 <sup>m</sup> 46 <sup>s</sup>	10	5				+1' 56.59	+0.05	+1 56.64	+1.16
12 49 46	10	5	-0' 39.48	-0.01	-0' 39.49				+0.545
12 56 11	10	5				+1 42.16	+0.05	+1 42.21	+1.37
13 4 55	10	5				+1 32.68	+0.05	+1 32.73	+4.54
13 10 8	10	5	-0 11 94	+0.01	-0 11.93				+0.548
13 15 51	10	6				+1 19.56	+0.06	+1 19.62	+4.72
13 24 53	10	6				+1 9.96	+0.07	+1 10.03	+4.89
13 30 19	10	5	+0 12.95	+0.05	+0 13.00				+0.457
13 35 11	10	5				+0 57.98	+0.09	+0 58.07	+5.07
13 45 12	10	5				+0 47.25	+0.10	+0 47.35	+5.23
13 50 36	10	5	+0 34.15	+0.09	+0 34.24				+0.541
13 57 19	10	5				+0 33.39	+0.12	+0 33.51	+5.44
Jan. 2 5 17 14	10.5	5				-3 13.20	-0.05	-3 13.25	+1.27
5 23 23	10.5	5	-0 13.97	-0.02	-0 13.99				-0.251
5 27 16	10.5	5	-0 9.25	-0.02	-0 9.27				-0.242
5 32 52	10.5	5				-3 29.53	-0.06	-3 29.59	+1.15
6 0 39	10.5	5				-3 58.81	-0.09	-3 58.90	+0.97
6 6 38	10.5	5	+0 37.98	0.00	+0 37.98				-0.157
6 10 15	10.5	5	+0 42.51	0.00	+0 42.51				-0.148
6 15 46	10.5	5				-4 15.01	-0.09	-4 15.10	+0.90
7 5 31	10.5	5				-5 8.07	-0.09	-5 8.16	+0.78
7 14 24	10.5	5	+1 58.81	+0.03	+1 58.84				+0.002
7 21 1	10.5	5				-5 24.68	-0.09	-5 24.77	+0.78
12 42 24	10	5				+0 44.55	-0.03	+0 44.52	+4.17
12 48 32	10	5	-0 58.91	-0.05	-0 58.96				+0.541
12 53 15	10	5	-0 52.05	-0.05	-0 52.10				+0.542
12 57 39	10	5				+0 27.20	-0.02	+0 27.18	+4.44
13 10 8	10	5				+0 13.12	-0.02	+0 13.10	+4.65
13 17 12	10	7	-0 20.92	-0.02	-0 20.94				+0.544
13 22 55	10	5	-0 14.33	-0.02	-0 14.35				+0.544
13 28 58	10	5				-0 8.28	-0.02	-0 8.30	+4.98
13 35 4	10	5				-0 14.99	-0.01	-0 15.00	+5.10
13 40 38	10	5	+0 7.96	0.00	+0 7.96				+0.540
13 45 28	10	5				-0 26.36	0.01	-0 26.37	+5.27
Jan. 3 5 29 14	1	5				+0 57.55	+0.01	+0 57.56	+1.21
5 33 46	2	5				-2 52.00	-0.05	-2 52.05	+1.18
5 39 37	1	5	+0 25.08	0.01	+0 25.09				-0.211
5 43 33	2	4	+0 17.43	0.00	+0 17.43				-0.203
5 48 12	1	5				+0 37.31	+0.01	+0 37.32	+1.08
5 51 57	2	5				-3 11.65	-0.06	-3 11.71	+1.06
6 21 25	1	3				+0 2.43	0.00	+0 2.43	+0.92
6 23 5	1	3				0 0.00	0.00	0 0.00	+0.92
6 24 41	1	2				-0 1.06	0.00	-0 1.06	+0.91
6 30 32	1	5	+1 38.88	+0.03	+1 38.91				0.076
6 43 54	1	5				-0 21.65	-0.01	-0 21.66	+0.86
10 36 0	1	5				-0 33.68	-0.05	-0 33.73	+2.30
10 40 19	2	5				+0 6.37	-0.02	+0 6.35	+2.35
10 44 14	3	5				+1 22.16	+0.01	+1 22.17	+2.41
10 48 2	4	5				+1 30.54	-0.01	+1 30.53	+2.46
10 55 44	1	5	-2 7.51	-0.06	-2 7.57				+0.450
11 0 31	2	5	-0 39.33	-0.02	-0 39.35				+0.457
11 4 44	3	5	-1 11.28	-0.04	-1 11.32				+0.462
11 9 6	4	5	-1 57.59	-0.07	-1 57.66				+0.468
11 15 51	1	5				-1 18.25	-0.06	-1 18.31	+2.85
11 19 36	2	5				-0 37.52	-0.02	-0 37.54	+2.91
11 23 42	3	5				+0 37.69	-0.04	+0 37.65	+2.97
11 27 30	4	5				+0 45.70	-0.02	+0 45.68	+3.03
11 38 38	1	5				-1 43.96	-0.07	-1 44.03	+3.20
11 42 59	2	5				-1 3.77	-0.02	-1 3.79	+3.26
11 47 36	3	5				+0 10.62	0.00	+0 10.62	+3.34
11 52 13	4	5				+0 18.00	-0.02	+0 17.98	+3.42
11 59 39	3	6	0 0.00	0.00	0 0.00				+0.516
11 59 55	1	5	-0 44.37	-0.03	-0 44.40				+0.516
12 6 0	2	5	+0 44.85	+0.03	+0 44.88				+0.521
12 9 41	3	5	+0 12.86	+0.01	+0 12.87				+0.522
12 13 52	4	5	-0 33.31	-0.03	-0 33.34				+0.525
12 19 52	1	5				-2 30.25	-0.08	-2 30.33	+3.86
12 24 0	2	5				-1 50.36	-0.01	-1 50.37	+3.95
12 28 28	3	5				-0 34.75	+0.01	-0 34.74	+4.02

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Hour	Min	Sec	Comp. Sign	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$
Jan. 3	12	32	6	4	5	.....	.....	.....	-0 26.20	-0.02	-0 26.22	+4.08
	12	58	7	3	5	.....	.....	.....	-1 8.51	+0.03	-1 8.48	+4.53
	13	8	14	4	5	.....	.....	.....	-1 6.95	-0.01	-1 6.96	+4.59
	13	13	31	3	5	+1 37.17	+0.10	+1 37.27	.....	.....	.....	+0.542
	13	18	19	4	5	+0 50.85	+0.04	+0 50.89	.....	.....	.....	+0.541
	13	26	35	3	4	.....	.....	.....	1 40.67	+0.05	-1 40.62	+5.00
Jan. 8	5	55	39	1	5	.....	.....	.....	-1 42.37	-0.04	-1 42.41	+1.33
	6	2	7	1	5	+1 45.28	+0.03	+1 45.31	.....	.....	.....	-0.147
	6	8	39	1	5	.....	.....	.....	-1 56.18	-0.04	-1 56.22	+1.28
	6	14	5	2	5	.....	.....	.....	+2 10.26	+0.04	+2 10.30	+1.27
	6	19	10	3	5	.....	.....	.....	+0 7.47	+0.01	+0 7.48	+1.24
	6	24	28	2	5	-2 12.77	-0.03	-2 12.80	.....	.....	.....	-0.096
	6	28	38	3	5	-3 5.65	-0.05	-3 5.70	.....	.....	.....	-0.087
	6	33	48	2	5	.....	.....	.....	+1 49.28	+0.03	+1 49.31	+1.19
	6	37	55	3	5	.....	.....	.....	-0 12.54	0.00	-0 12.54	+1.18
	6	54	5	2	5	.....	.....	.....	+1 27.61	+0.03	+1 27.64	+1.16
	6	59	36	3	5	.....	.....	.....	-0 35.88	-0.02	-0 35.90	+1.15
	7	7	29	2	5	-1 12.19	-0.02	-1 12.21	.....	.....	.....	+0.002
	7	11	0	3	5	-2 6.05	-0.04	-2 6.09	.....	.....	.....	+0.009
	7	16	22	2	5	.....	.....	.....	+1 3.67	+0.02	+1 3.69	+1.15
	7	19	40	3	5	.....	.....	.....	-0 56.86	-0.02	-0 56.88	+1.16
	7	59	41	2	5	.....	.....	.....	+0 16.80	+0.01	+0 16.81	+1.26
	8	4	10	3	5	.....	.....	.....	-1 45.29	-0.03	-1 45.32	+1.27
	8	9	44	2	5	+0 15.75	0.00	+0 15.75	.....	.....	.....	+0.143
	8	14	9	3	5	-0 36.69	-0.01	-0 36.70	.....	.....	.....	+0.152
	8	18	46	2	5	.....	.....	.....	-0 3.81	+0.01	-0 3.80	+1.33
	8	22	42	3	6	.....	.....	.....	-2 5.36	-0.04	-2 5.40	+1.35
Jan. 12	6	5	29	11	5	.....	.....	.....	-2 3.08	0.04	-2 3.12	+1.52
	6	10	47	11	6	-0 27.74	0.01	-0 27.75	.....	.....	.....	-0.114
	6	15	51	11	5	.....	.....	.....	2 14.14	-0.04	-2 14.48	+1.48
Jan. 14	5	58	52	1	5	.....	.....	.....	+0 3.21	-0.01	+0 3.20	+1.65
	6	3	49	2	5	.....	.....	.....	-2 55.85	-0.05	-2 55.90	+1.63
	6	9	56	1	5	+4 22.32	+0.08	+4 22.40	.....	.....	.....	-0.111
	6	14	39	2	5	-1 24.63	-0.02	-1 24.65	.....	.....	.....	-0.102
	6	20	12	1	5	.....	.....	.....	-0 19.29	-0.01	-0 19.30	+1.58
	6	24	44	2	5	.....	.....	.....	-3 17.89	-0.06	-3 17.95	+1.57
	6	49	54	2	5	.....	.....	.....	-3 44.39	-0.07	-3 44.46	+1.44
	6	57	49	2	5	-0 16.09	0.00	-0 16.09	.....	.....	.....	-0.005
	7	2	34	2	5	.....	.....	.....	-3 58.00	-0.07	-3 58.07	+1.43
	8	43	31	11.5	5	.....	.....	.....	+1 2.24	+0.02	+1 2.26	+1.88
	8	49	10	11.5	5	+0 9.69	0.00	+0 9.69	.....	.....	.....	+0.235
	8	54	24	11.5	5	.....	.....	.....	+0 50.78	+0.02	+0 50.80	+1.45
	9	16	59	11.5	5	.....	.....	.....	+0 26.01	+0.02	+0 26.03	+2.14
	9	23	32	11.5	5	+1 5.23	+0.02	+1 5.25	.....	.....	.....	+0.301
	9	28	52	11.5	5	.....	.....	.....	+0 13.38	+0.01	+0 13.39	+2.25
	9	47	23	11.5	5	.....	.....	.....	-0 7.31	+0.02	-0 7.29	+2.43
	9	52	57	11.5	5	-1 52.50	+0.05	+1 52.55	.....	.....	.....	+0.352
	9	58	28	11.5	5	.....	.....	.....	-0 19.15	+0.02	-0 19.13	+2.55
	10	25	32	9	5	.....	.....	.....	-1 21.26	-0.05	-1 21.31	+2.84
	10	30	53	9	5	-1 21.03	-0.03	-1 21.06	.....	.....	.....	+0.409
	10	36	20	9	6	.....	.....	.....	-1 33.20	-0.05	-1 33.25	+2.97
	10	53	31	9	5	.....	.....	.....	-1 51.84	-0.05	-1 51.89	+3.19
	10	58	52	9	5	-0 35.22	0.00	-0 35.22	.....	.....	.....	+0.444
	11	3	51	9	6	.....	.....	.....	-2 3.29	-0.06	-2 3.35	+3.33
	11	55	4	9	5	.....	.....	.....	-3 0.01	-0.06	-3 0.07	+4.04
	12	0	57	9	5	+1 7.82	+0.05	+1 7.87	.....	.....	.....	+0.496
	12	6	18	9	5	.....	.....	.....	-3 12.03	-0.06	-3 12.69	+4.20
	12	21	21	9	5	.....	.....	.....	-3 32.61	-0.05	-3 32.66	+4.48
	12	30	10	9	5	-1 56.42	+0.08	+1 56.50	.....	.....	.....	+0.508
	12	36	26	9	5	.....	.....	.....	-3 46.03	-0.05	-3 46.08	+4.65
Jan. 16	5	43	5	12	5	.....	.....	.....	+0 19.42	+0.01	+0 19.43	+1.99
	5	48	18	12	5	-1 17.96	-0.02	-1 17.98	.....	.....	.....	-0.152
	5	53	38	12	5	-1 9.71	-0.02	-1 9.73	.....	.....	.....	-0.142
	5	59	4	12	5	.....	.....	.....	+0 2.72	0.00	+0 2.72	+1.92
	6	1	6	12	4	.....	.....	.....	-0 2.47	0.00	-0 2.47	+1.90
	6	22	30	12	5	.....	.....	.....	-0 21.69	-0.01	-0 21.70	+1.70
	6	26	57	12	5	-0 14.11	0.00	-0 14.11	.....	.....	.....	-0.071

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date 1900 90 Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Jan.16 6 <sup>h</sup> 31 <sup>m</sup> 35 <sup>s</sup>	12	5	.....	.....	.....	-0 31.13	-0.01	-0 31.14	..... +1.68
6 49 40	12	5	.....	.....	.....	-0 50.50	-0.01	-0 50.51	..... +1.66
6 54 43	12	5	+0 31.79	+0.01	+0 31.70	.....	.....	.....	..... -0.011
6 59 33	12	5	.....	.....	.....	-1 0.64	-0.02	-1 0.66	..... +1.65
7 8 24	12	5	.....	.....	.....	-1 10.33	-0.02	-1 10.35	..... +1.66
7 12 39	12	5	+1 1.28	+0.02	+1 1.30	.....	.....	.....	..... +0.029
7 16 57	12	5	.....	.....	.....	-1 19.05	-0.02	-1 19.07	..... +1.67
Jan.18 10 57 5	12.5	5	-0 15.18	-0.01	-0 15.19	.....	.....	.....	..... +0.436
11 2 59	12.5	6	.....	.....	.....	-0 3.24	0.00	-0 3.24	..... +3.54
11 8 56	12.5	5	+0 4.96	0.00	+0 4.96	.....	.....	.....	..... +0.448
11 13 54	12.5	5	.....	.....	.....	-0 14.66	0.00	-0 14.66	..... +3.68
11 18 15	12.5	5	+0 21.87	+0.01	+0 21.88	.....	.....	.....	..... +0.457
11 23 38	12.5	5	.....	.....	.....	-0 25.36	0.00	-0 25.36	..... +3.80
11 29 18	12.5	5	+0 41.39	+0.03	+0 41.42	.....	.....	.....	..... +0.466
11 33 23	12.5	5	.....	.....	.....	-0 36.26	+0.01	-0 36.25	..... +3.94
11 41 16	12.5	5	+1 2.46	+0.04	+1 2.50	.....	.....	.....	..... +0.476
11 45 19	12.5	5	.....	.....	.....	-0 49.22	+0.01	-0 49.21	..... +4.10
Jan.19 5 32 41	1	5	.....	.....	.....	-1 42.82	-0.04	-1 42.86	..... +2.08
5 37 51	1	5	+2 49.72	+0.04	+2 49.76	.....	.....	.....	..... -0.171
5 43 5	1	5	.....	.....	.....	-1 53.51	-0.04	-1 53.55	..... +2.03
5 47 26	2	5	.....	.....	.....	-1 44.55	-0.03	-1 44.58	..... +2.01
5 52 6	1	5	.....	.....	.....	-2 3.05	-0.05	-2 3.10	..... +1.99
5 56 12	2	5	-0 42.16	-0.01	-0 42.17	.....	.....	.....	..... -0.131
6 1 27	1	5	+3 30.86	+0.06	+3 30.92	.....	.....	.....	..... -0.121
6 6 7	3	2	.....	.....	.....	-2 5.47	-0.04	-2 5.51	..... +1.93
6 12 2	1	6	.....	.....	.....	-2 23.62	-0.05	-2 23.67	..... +1.92
6 37 0	2	5	.....	.....	.....	-2 36.21	-0.05	-2 36.26	..... +1.87
6 45 49	2	5	+0 43.97	+0.02	+0 43.99	.....	.....	.....	..... -0.026
6 50 23	2	5	.....	.....	.....	-2 50.07	-0.05	-2 50.12	..... +1.86
6 55 44	3	5	.....	.....	.....	-0 8.13	0.00	-0 8.13	..... +1.86
7 0 11	3	5	+1 40.57	+0.03	+1 40.60	.....	.....	.....	..... +0.007
7 4 44	3	5	.....	.....	.....	-0 17.46	0.00	-0 17.46	..... +1.86
8 29 29	12	5	.....	.....	.....	-0 43.67	-0.02	-0 43.69	..... +2.12
8 36 33	12	7	-1 6.30	-0.02	-1 6.32	.....	.....	.....	..... +0.209
8 42 6	12	5	.....	.....	.....	-0 56.51	-0.02	-0 56.53	..... +2.20
8 48 20	12	5	.....	.....	.....	-1 3.61	-0.02	-1 3.61	..... +2.24
8 52 54	12	5	-0 38.21	-0.01	-0 38.22	.....	.....	.....	..... +0.240
8 59 3	12	5	.....	.....	.....	-1 14.85	-0.03	-1 14.88	..... +2.31
9 8 50	12	5	.....	.....	.....	-1 25.50	-0.03	-1 25.53	..... +2.39
9 12 37	12	5	-0 3.63	0.00	-0 3.63	.....	.....	.....	..... +0.279
9 15 58	12	5	.....	.....	.....	-1 33.54	-0.03	-1 33.57	..... +2.44
Jan.20 5 46 15	10	5	.....	.....	.....	-2 40.86	-0.06	-2 40.91	..... +2.07
5 52 21	10	5	+1 37.73	+0.03	+1 37.76	.....	.....	.....	..... -0.137
5 58 15	10	5	.....	.....	.....	-2 53.38	0.06	-2 53.44	..... +2.02
6 15 7	10	5	.....	.....	.....	-3 11.28	-0.06	-3 11.34	..... +1.97
6 20 35	10	5	+2 26.69	+0.04	+2 26.73	.....	.....	.....	..... -0.078
6 25 42	10	5	.....	.....	.....	-3 22.31	-0.06	-3 22.37	..... +1.95
6 49 5	10	5	.....	.....	.....	-3 46.81	-0.07	-3 46.88	..... +1.93
6 55 56	10	5	+3 29.36	+0.06	+3 29.42	.....	.....	.....	..... -0.002
7 2 36	10	5	.....	.....	.....	-4 1.16	-0.07	-4 1.23	..... +1.93
10 37 59	1	5	.....	.....	.....	+0 59.83	+0.02	+0 59.85	..... +3.32
10 42 2	2	5	.....	.....	.....	+2 9.02	+0.02	+2 9.04	..... +3.38
10 46 56	1	5	-0 6.33	0.00	-0 6.33	.....	.....	.....	..... +0.421
10 51 14	2	5	-1 29.69	-0.05	-1 29.74	.....	.....	.....	..... +0.430
10 55 17	1	5	+0 9.03	+0.01	+0 9.04	.....	.....	.....	..... +0.432
11 0 51	2	4	-1 11.95	-0.04	-1 11.99	.....	.....	.....	..... +0.437
11 6 7	1	5	.....	.....	.....	+0 28.92	+0.02	+0 28.94	..... +3.66
11 9 52	2	5	.....	.....	.....	+1 38.91	+0.02	+1 38.93	..... +3.70
11 23 44	1	5	.....	.....	.....	+0 9.79	+0.03	+0 9.82	..... +3.88
11 28 32	2	5	.....	.....	.....	+1 17.85	+0.03	+1 17.88	..... +3.95
11 33 11	1	5	+1 17.81	+0.07	+1 17.88	.....	.....	.....	..... +0.467
11 37 30	2	5	-0 5.78	+0.03	-0 5.75	.....	.....	.....	..... +0.470
11 42 14	1	5	+1 33.58	+0.07	+1 33.65	.....	.....	.....	..... +0.474
11 47 10	2	5	+0 11.61	+0.02	+0 11.63	.....	.....	.....	..... +0.477
11 53 18	1	5	.....	.....	.....	-0 22.56	+0.05	-0 22.51	..... +4.28
11 58 17	2	6	.....	.....	.....	+0 45.62	+0.04	+0 45.66	..... +4.34
Jan.21 10 27 58	9	5	-0 7.37	0.00	-0 7.37	.....	.....	.....	..... +0.396

## MICROMETRICAL OBSERVATIONS OF EROS—Continued

Date	Hour	Min	Sec	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$	$\Delta\delta$
Jan. 21	10	33	18	9	5	.....	.....	.....	-3 6.02	0.07	-3 6.09	.....	+3.31
	10	38	29	9	5	+0 12.19	0.00	+0 12.19	.....	.....	.....	+0.410	.....
	10	47	54	9	5	+0 29.61	+0.01	+0 29.62	.....	.....	.....	+0.420	.....
	10	53	43	9	5	.....	.....	.....	-3 28.46	-0.07	-3 28.53	.....	+3.56
	10	59	17	9	5	+0 50.25	+0.02	+0 50.27	.....	.....	.....	+0.434	.....
Jan. 22	11	56	46	1	6	.....	.....	.....	-2 6.73	-0.03	-2 6.76	.....	+4.42
	12	5	22	1	5	+1 13.60	+0.03	+1 13.63	.....	.....	.....	+0.481	.....
	12	12	19	1	5	.....	.....	.....	-2 23.86	-0.03	-2 23.92	.....	+4.61
	12	18	9	1	5	.....	.....	.....	+1 41.21	+0.01	+1 41.22	.....	+1.69
	12	23	58	2	5	-1 3.70	-0.03	-1 3.73	.....	.....	.....	+0.489	.....
	12	28	3	2	5	.....	.....	.....	+1 30.64	+0.01	+1 30.65	.....	+4.81
Jan. 24	6	2	50	1	5	-4 26.48	+0.08	-4 26.56	.....	.....	.....	-0.110	.....
	6	10	0	1	5	.....	.....	.....	+3 10.27	+0.05	+3 10.32	.....	+2.12
	6	17	15	1	5	+4 53.70	+0.08	+4 53.78	.....	.....	.....	-0.081	.....
	9	20	54	2	5	.....	.....	.....	+1 52.51	+0.05	+1 52.56	.....	+2.77
	9	26	54	2	5	+2 11.20	+0.05	+2 11.25	.....	.....	.....	+0.304	.....
	9	32	37	2	5	.....	.....	.....	+1 40.98	+0.05	+1 41.03	.....	+2.87
	9	39	56	2	5	.....	.....	.....	+1 33.73	+0.05	+1 33.78	.....	+2.93
	9	44	39	2	5	+2 45.92	+0.06	+2 45.98	.....	.....	.....	+0.333	.....
	9	49	24	2	5	.....	.....	.....	+1 24.74	+0.06	+1 24.80	.....	+3.01
Jan. 25	5	43	32	1	5	.....	.....	.....	-0 19.00	0.00	-0 19.00	.....	+2.38
	5	47	32	1	4	-2 31.63	-0.05	-2 31.68	.....	.....	.....	-0.143	.....
	5	51	56	1	5	.....	.....	.....	-0 27.67	0.00	-0 27.67	.....	+2.35
	5	55	40	2	5	.....	.....	.....	-1 7.13	-0.03	-1 7.16	.....	+2.34
	5	59	35	3	5	.....	.....	.....	-2 4.89	-0.05	-2 4.94	.....	+2.32
	6	3	54	2	5	+3 17.99	+0.06	+3 18.05	.....	.....	.....	-0.110	.....
	6	7	15	3	5	+3 23.72	+0.06	+3 23.78	.....	.....	.....	-0.106	.....
	6	12	45	2	5	.....	.....	.....	-1 24.00	-0.03	-1 24.03	.....	+2.29
	6	15	46	3	5	.....	.....	.....	-2 21.72	-0.05	-2 21.77	.....	+2.28
	6	21	10	1	5	.....	.....	.....	-1 0.86	-0.01	-1 0.87	.....	+2.26
	6	28	29	1	3	+1 48.92	Not	Eros. An	11 <sup>m</sup> star	.....	.....	.....	.....
	6	32	31	1	5	-1 7.21	-0.02	-1 7.23	.....	.....	.....	-0.049	.....
	6	39	35	1	5	-0 59.44	-0.02	-0 59.46	.....	.....	.....	-0.041	.....
	6	40	55	1	5	.....	.....	.....	-1 17.92	+0.02	-1 17.90	.....	+2.21
	6	47	54	4	5	.....	.....	.....	+0 23.79	+0.01	+0 23.80	.....	+2.23
	6	51	28	1	5	.....	.....	.....	-1 28.96	+0.02	-1 28.94	.....	+2.23
	6	57	8	4	5	+0 49.51	+0.01	+0 49.52	.....	.....	.....	+0.002	.....
	7	0	40	1	5	-0 14.34	0.00	-0 14.34	.....	.....	.....	+0.010	.....
	7	1	41	1	5	-0 6.65	0.00	-0 6.65	.....	.....	.....	+0.019	.....
	7	9	18	4	3	.....	.....	.....	+0 2.14	0.00	+0 2.14	.....	+2.24
	7	12	2	4	2	.....	.....	.....	-0 1.40	0.00	-0 1.40	.....	+2.24
	7	15	43	1	5	.....	.....	.....	-1 54.11	-0.03	-1 54.14	.....	+2.21
	7	41	39	1	5	.....	.....	.....	-2 21.20	-0.04	-2 21.24	.....	+2.29
	7	48	55	1	5	+1 16.45	+0.02	+1 16.47	.....	.....	.....	+0.112	.....
	7	53	50	1	5	+1 25.32	+0.03	+1 25.35	.....	.....	.....	+0.123	.....
	7	58	36	1	5	.....	.....	.....	-2 38.63	-0.05	-2 38.68	.....	+2.35
Jan. 27	6	45	53	13	5	+3 6.27	+0.05	+3 6.32	.....	.....	.....	-0.017	.....
	6	52	30	13	5	.....	.....	.....	+0 40.92	+0.01	+0 40.93	.....	+2.35
	6	57	36	13	5	+3 29.28	+0.06	+3 29.34	.....	.....	.....	+0.008	.....
Jan. 28	6	57	18	13	5	+1 11.52	+0.02	+1 11.54	.....	.....	.....	+0.006	.....
	7	2	16	13	5	.....	.....	.....	+1 55.18	+0.04	+1 55.22	.....	+2.12
	7	6	56	13	5	+1 30.39	+0.02	+1 30.41	.....	.....	.....	+0.027	.....
Feb. 1	5	52	19	10	5	-2 43.14	-0.05	-2 43.19	.....	.....	.....	-0.239	.....
	5	58	36	10	5	.....	.....	.....	+1 39.76	+0.04	+1 39.80	.....	+2.72
	6	5	0	10	5	-2 18.24	-0.04	-2 18.28	.....	.....	.....	-0.215	.....
	6	24	11	10	5	-1 39.76	-0.03	-1 39.79	.....	.....	.....	-0.179	.....
	6	29	32	10	5	.....	.....	.....	+1 8.93	+0.02	+1 8.95	.....	+2.66
	6	34	37	10	5	-1 18.61	-0.02	-1 18.63	.....	.....	.....	-0.159	.....
	6	50	39	10	5	-0 46.60	-0.01	-0 46.61	.....	.....	.....	-0.128	.....
	6	55	39	10	5	.....	.....	.....	+0 42.48	+0.01	+0 42.49	.....	+2.65
	6	59	38	10	5	-0 28.82	-0.01	-0 28.83	.....	.....	.....	+0.138	.....
	7	5	15	10	5	-0 17.34	-0.01	-0 17.35	.....	.....	.....	+0.150	.....
	7	11	49	10	5	.....	.....	.....	+0 26.03	+0.01	+0 26.04	.....	+2.66
	7	16	6	10	5	+0 1.31	0.00	+0 1.34	.....	.....	.....	+0.171	.....

MICROMETRICAL OBSERVATIONS OF *EROS*—Continued

Date—1900 or Time	Comp. Star	No. Obs.	Measured $\Delta\alpha$	Ref.	Corrected $\Delta\alpha$	Measured $\Delta\delta$	Ref.	Corrected $\Delta\delta$	Parallax Factors $\Delta\alpha$ $\Delta\delta$
Feb. 4 9 <sup>h</sup> 33 <sup>m</sup> 5 <sup>s</sup>	10.5	5	.....	.....	.....	+1' 24.70	0.00	+1' 24.70	.....
9 39 8	10.5	5	-2' 20.64	-0.06	-2' 20.70	.....	.....	.....	+0.316
9 45 30	10.5	6	.....	.....	.....	+1 11.44	0.00	+1 11.44	+3.55
10 21 36	10.5	5	.....	.....	.....	+0 34.43	0.00	+0 34.43	+3.85
10 26 3	10.5	5	-0 43.43	-0.02	-0 43.45	.....	.....	.....	+0.380
10 30 36	10.5	5	.....	.....	.....	+0 25.37	0.00	+0 25.37	+3.94
10 40 44	10.5	5	.....	.....	.....	+0 15.00	0.00	+0 15.00	+4.03
10 44 57	10.5	4	-0 3.62	0.00	-0 3.62	.....	.....	.....	+0.402
10 46 53	10.5	est.	0 0.00	0.00	0 0.00	.....	.....	.....	+0.404
10 48 19	10.5	2	+0 2.63	0.00	+0 2.63	.....	.....	.....	+0.405
10 52 46	10.5	7	.....	.....	.....	+0 2.63	0.00	+0 2.63	+4.17
Feb. 5 6 5 27	1	5	+1 7.41	+0.02	+1 7.43	.....	.....	.....	-0.086
6 9 47	2	5	-2 16.64	-0.04	-2 16.68	.....	.....	.....	-0.088
6 16 25	1	5	.....	.....	.....	+0 20.19	0.00	+0 20.19	+2.93
6 19 52	2	2	.....	.....	.....	+0 1.50	0.00	+0 1.50	+2.92
6 23 27	2	3	.....	.....	.....	-0 2.46	0.00	-0 2.46	+2.91
6 29 7	1	5	+1 55.93	+0.03	+1 55.96	.....	.....	.....	-0.047
6 33 28	2	5	-1 28.09	-0.03	-1 28.12	.....	.....	.....	-0.039
6 35 18	2	6	-1 3.70	-0.02	-1 3.72	.....	.....	.....	-0.015
6 41 57	2	6	.....	.....	.....	-0 30.40	-0.01	-0 30.41	+2.89
6 56 47	2	5	-0 39.73	-0.01	-0 39.74	.....	.....	.....	+0.008
7 5 34	2	5	-0 22.22	-0.01	-0 22.23	.....	.....	.....	+0.027
7 10 45	2	5	.....	.....	.....	-0 49.18	-0.01	-0 49.19	+2.90
7 15 10	2	5	-0 2.43	0.00	-0 2.43	.....	.....	.....	+0.047
7 17 16	2	2	+0 2.24	0.00	+0 2.24	.....	.....	.....	+0.051
10 7 29	10	5	-1 43.36	0.05	-1 43.41	.....	.....	.....	+0.355
10 13 38	10	5	.....	.....	.....	-0 13.83	-0.03	-0 13.86	+3.82
10 20 6	10	5	-1 17.10	-0.04	-1 17.14	.....	.....	.....	+0.372
10 29 51	10	5	-0 56.84	-0.03	-0 56.87	.....	.....	.....	+0.383
10 34 41	10	5	.....	.....	.....	-0 34.83	-0.03	-0 34.86	+4.01
10 39 56	10	5	-0 35.80	-0.02	0 35.82	.....	.....	.....	+0.396
10 47 43	10	5	-0 19.53	-0.02	-0 19.55	.....	.....	.....	+0.403
10 52 46	10	5	.....	.....	.....	-0 53.43	-0.03	-0 53.46	+4.17
10 56 0	10	1	-0 1.63	-0.01	-0 1.64	.....	.....	.....	+0.412
10 58 39	10	4	+0 3.26	-0.01	+0 3.25	.....	.....	.....	+0.414

## COMPARISON STARS

The following table contains the comparison stars used in these measures. The accurate positions of these stars are now being photographically measured in Europe and are not yet available.

Date	Star	Mag.	Time	Remarks
Oct. 2	1	10.5	8 <sup>h</sup> 12 <sup>m</sup> to 8 <sup>h</sup> 38 <sup>m</sup>	Same star both times
	2	11.0	8 12 to 8 38	
	8.6	8.6	8 50 to 9 03 and 11 32 to 11 52	
	<i>Eros</i>	10.5	.....	
Oct. 3	12	12	16 46 to 17 4	1855.0 $\alpha$ 2 <sup>h</sup> 40 <sup>m</sup> 15.0 <sup>s</sup> = +47° 25' 0"
	1	10	12 50 to 13 18	
	2	10.8	12 50 to 13 18	
	10.3	10.3	11 59 to 12 13	
Oct. 4	<i>Eros</i>	10	.....	1855.0 $\alpha$ 2 <sup>h</sup> 40 <sup>m</sup> 15.0 <sup>s</sup> = +47° 25' 0"
	1	12	7 27 to 8 11	
	2	12	7 27 to 8 11	
	.....	9.5	8 32 and 12 36 to 13 10	
Oct. 8	1	13	16 42 to 17 5	1855.0 $\alpha$ 2 <sup>h</sup> 40 <sup>m</sup> 15.0 <sup>s</sup> = +47° 25' 0"
	2	12.5	16 42 to 17 5	
	9.8	9.8	17 9 to 17 36	
	.....	12.2	7 15 to 8 47	
Oct. 9	1	12	7 15 to 8 47	1855.0 $\alpha$ 2 <sup>h</sup> 40 <sup>m</sup> 15.0 <sup>s</sup> = +47° 25' 0"
	2	12	7 15 to 8 47	
	3	12.5	7 15 to 8 47	
	<i>Eros</i>	10	.....	
Oct. 10	1	9	14 11 to 14 32	1855.0 $\alpha$ 2 <sup>h</sup> 40 <sup>m</sup> 15.0 <sup>s</sup> = +47° 25' 0"
	.....	9.8	16 19 to 17 41	
	2	10	16 19 to 17 41	
	.....	12.7	12 50 to 13 2	
Oct. 11	1	12.5	6 44 to 8 4	.....

COMPARISON STARS - *Continued*

Date	Star	Magnitude	Time	Remarks
Oct. 11	2	12.5	6 <sup>h</sup> 44 <sup>m</sup> to 8 <sup>h</sup> 4 <sup>m</sup>	
	1	12	13 47 to 14 7	
	2	12.5	13 47 to 14 7	
	1	12.5	16 32 to 17 31	
	2	12	16 32 to 17 31	
Oct. 14	1	12.5	7 17 to 7 34	
	2	10	7 17 to 7 34	
	1	...	16 57 to 17 45	
	2	...	16 57 to 17 45	
Oct. 15	1	10	6 41 to 7 22	
	2	10.5	6 41 to 7 22	
Oct. 16	1	12	6 38 to 7 33	
	2	12.5	6 38 to 7 33	
	3	12	6 38 to 7 33	
	7.8	7.8	12 30 to 12 56	
	1	7.8	16 40 to 17 50	{ Same star
	2	10	16 40 to 17 50	
Oct. 17		10.5	7 9 to 7 30	
		10	11 41 to 11 57	
	1	A little fainter than Eros	16 56 to 17 46	
	2		16 56 to 17 46	
Oct. 18	...	9.2	16 3 to 16 17	
Oct. 25	1	12	6 18 to 7 52	
	2	10.5	6 18 to 7 52	
	1	10.5	11 31 to 11 45	{ Same star
	2	10.5	16 31 to 17 51	
Oct. 26	1	10.5	16 31 to 17 51	
	2	12.5	5 55 to 6 33	Same as * 1 at 11 <sup>h</sup> 56 <sup>m</sup> to 12 <sup>h</sup> 11 <sup>m</sup>
	1	12	6 14 to 6 27	
	2	11	11 56 to 12 11	Same as * 1 at 5 <sup>h</sup> 55 <sup>m</sup> to 9 <sup>h</sup> 3 <sup>m</sup>
	3	11	16 25 to 17 36	
	2	11	16 25 to 17 36	
	3	11	16 25 to 17 36	
Oct. 27	1	12	9 7 to 9 30	
	2	13	9 34 to 9 47	
Oct. 30	...	11	15 52 to 16 12	
Nov. 1	1	10	5 55 to 6 56	
	2	11	5 55 to 6 56	
	3	10.5	5 55 to 6 56	
	4	9.2	5 55 to 6 56	
	1	...	8 10 to 9 0	
	2	...	8 10 to 9 0	
	3	...	8 10 to 9 0	
	1	9.8	16 46 to 18 1	
	2	10	16 46 to 18 1	
	3	10	16 46 to 18 1	
Nov. 2	1	10.5	5 12 to 6 39	Same as * 1 8 <sup>h</sup> 9 <sup>m</sup> to 8 <sup>h</sup> 44 <sup>m</sup>
	2	12.5	5 42 to 6 39	
	3	10	5 42 to 6 39	Same as * 3 8 9 to 8 44
	1	10.5	8 9 to 8 44	Same as * 1 5 42 to 6 39
	3	10	8 9 to 8 44	Same as * 3 5 42 to 6 39
	4	...	8 9 to 8 44	
	1	10.2	12 17 to 12 58	Same as * 1 16 56 to 18 8
	2	9.9	12 17 to 12 58	Same as * 2 16 56 to 18 8
	1	10.2	16 56 to 18 8	Same as * 1 12 17 to 12 58
	2	9.9	16 56 to 18 8	Same as * 2 12 17 to 12 58
	3	11	16 56 to 18 8	
Nov. 3	1	11	5 39 to 8 32	
	2	9.5	5 39 to 8 32	
	10	10	10 52 to 11 10	
	9.5	9.5	11 18 to 11 31	
	1	10.5	16 18 to 18 6	
	2	10.5	16 18 to 18 6	
	3	12	16 18 to 18 6	
Nov. 4	1	11.5	6 2 to 8 30	
	2	11	6 2 to 8 30	
	3	10	6 2 to 8 30	Same as * 3 10 26 to 10 40
	4	11	6 2 to 8 30	Same as * 4 10 26 to 10 40
	1	11	10 26 to 10 35	
	3	10	10 30 to 10 40	
	1	10	16 21 to 18 11	

COMPARISON STARS *Continued*

Date	Star	Magnitude	Time	Remarks
Nov. 4	2	10	16 <sup>h</sup> 21 <sup>m</sup> to 18 <sup>h</sup> 11 <sup>m</sup>	
Nov. 5	1	13	5 37 to 7 51	
	2	13.5	5 37 to 7 51	
	3	12	5 37 to 7 51	
	4	.....	5 37 to 7 51	
	5	14	5 37 to 7 51	
	6	12	5 37 to 7 51	Same as * 6 10 33 to 10 50
	7	10	5 37 to 7 51	
	6	12	10 33 to 10 50	Same as * 6 5 37 to 7 51
Nov. 6	...	12	10 23 to 10 28	
Nov. 7	1	11.5	13 8 to 13 16	
	2	11	13 8 to 13 16	
Nov. 8	1	11.5	5 50 to 8 18	
	2	11.5	5 50 to 8 18	
	3	11.5	5 50 to 8 18	
	1	11	16 16 to 17 52	
	2	11.5	16 16 to 17 52	
Nov. 10	1	Same as <i>Eros</i>	5 44 to 7 16	
	1	...	14 51 to 15 37	
	2	...	14 51 to 15 37	
	1	12	16 41 to 17 3	
	2	12	16 41 to 17 3	
	3	12	16 41 to 17 3	
Nov. 11	...	$\frac{1}{10}$ m less than <i>Eros</i>	6 28 to 6 49	
	...	$9.7 \frac{1}{10}$ m less than <i>Eros</i>	7 9 to 8 5	
Nov. 13	1	11	5 48 to 8 3	
	2	11	5 48 to 8 3	
	1	11	8 49 to 9 28	A new set of stars
	2	11	8 49 to 9 28	Same as * 2 11 24 to 11 59
	1	11	11 24 to 11 59	
	2	11	11 24 to 11 59	Same as * 2 8 49 to 9 28
	2	11	16 56 to 18 16	
	3	10	16 56 to 18 16	
Nov. 15	1	11.5	6 13 to 7 55	
	2	11	6 13 to 7 55	
Nov. 21	1	11	5 33 to 6 29	Same as * 1 below
	2	11	5 33 to 6 29	Same as * 2 below
	3	11	5 33 to 6 29	Same as * 3 below
	4	10	5 33 to 6 29	
	1	11	7 11 to 8 25	Same as * 1 5 33 to 6 29
	2	11	7 11 to 8 25	Same as * 2 5 33 to 6 29
	3	10	7 11 to 8 25	Same as * 3 5 33 to 6 29
Nov. 22	1	9.5	16 46 to 17 33	
	1	9.0	7 25 to 8 51	
	2	9.5	7 25 to 8 51	
	1	10	15 52 to 17 26	
	2	11	15 52 to 17 26	
Nov. 23	...	.5m fainter than <i>Eros</i>	9 45 to 10 2	
Nov. 25	1	9.7	6 33 to 9 12	
	2	9.0	6 33 to 9 12	
	2	9.0	15 18 to 17 58	{ Same star
	3	n. p. of two 10m stars	15 18 to 17 58	
	4	10 s. f. of the two	15 18 to 17 58	
Nov. 26	1	...	5 35 to 8 15	Same as * 1 12 14 to 12 59
	3	10	5 35 to 8 15	Same as * 3 Nov. 25
	4	10	5 35 to 8 15	Same as * 4 Nov. 25
	1	...	12 14 to 12 59	Same as * 1 5 35 to 8 15
	2	...	12 14 to 12 59	{ Same star
	2	...	15 15 to 16 58	
	5	11	15 15 to 16 58	
	6	11	15 15 to 16 58	
Nov. 27	7.7	7.7	5 21 to 8 13	
	1	11	5 21 to 8 13	
	2	11	5 21 to 8 13	
Nov. 29	1	9.5	5 31 to 8 31	
	2	9.8	5 31 to 8 31	
	3	11	5 31 to 8 31	
	...	11	15 42 to 16 44	
Dec. 1	1	11	15 30 to 16 26	
	2	10	15 30 to 16 26	
Dec. 2	1	12	5 42 to 6 16	

COMPARISON STARS — *Continued*

Date	Star	Magnitude	Time	Remarks
Dec. 2	2	11	5 <sup>h</sup> 42 <sup>m</sup> to 6 <sup>h</sup> 16 <sup>m</sup>	
	3	11	5 42 to 6 16	
Dec. 5	1	9.7	6 49 to 9 29	
	2	9.2	6 49 to 9 29	
	3	10m (11m star close n. p.)	6 49 to 9 29	
	4	.5m fainter than <i>Eros</i>	13 53 to 15 7	
	11	11m (s. of two 11m stars)	13 53 to 15 7	
Dec. 8		9.8	6 23 to 8 22	
		Nearly 1m fainter than <i>Eros</i>	12 53 to 14 58	
Dec. 9	11	11	13 50 to 14 12	
	1	11	5 19 to 8 12	
	2	11	5 19 to 8 12	
	3	11.5	5 19 to 8 12	
		11.5	14 58 to 15 51	
Dec. 10	1	10	5 21 to 7 52	
	2	10	5 21 to 7 52	
Dec. 11		10.5	5 2 to 7 26	
	1	11	13 51 to 15 37	
	2	9(?)	13 51 to 15 37	
Dec. 12	1	8.5	4 58 to 8 9	
	2	10m (1m fainter than <i>Eros</i> )	4 58 to 8 9	
	3	12	4 58 to 8 9	
Dec. 17	1	9	8 57 to 9 9	
	2	9.2	8 57 to 9 9	
Dec. 18	1	11	4 55 to 7 41	
	2	8.8	4 55 to 7 41	
	3	12	4 55 to 7 41	
	9	9	12 46 to 15 2	
Dec. 19	12	12	14 20 to 14 33	
	1	11	5 6 to 7 37	
	2	11	5 6 to 7 37	
	3	11	5 6 to 7 37	
	4	11	12 47 to 14 29	
	1	11	12 47 to 14 29	
	2	11	12 47 to 14 29	
	3	11	12 47 to 14 29	
Dec. 20	4	11	12 47 to 14 29	
Dec. 21		...	6 4 to 7 35	
	1	12.5	13 47 to 14 16	
	2	12.5	13 47 to 14 16	
Dec. 24	1	11	13 27 to 14 5	
	2	10.5	13 27 to 14 5	
Dec. 26	13	13	5 57 to 6 46	
Dec. 28	1	11.5	5 20 to 7 12	
	2	12.5	5 20 to 7 12	
	8	8	11 14 to 12 33	
	13	13	11 14 to 12 33	
Dec. 29	9.5	9.5	5 26 to 7 19	
	1	13	5 56 to 6 21	
	2	13	5 56 to 6 21	
Dec. 30	1	10.5	5 29 to 6 43	
	2	12	5 29 to 6 43	
Dec. 31	9.5	9.5	5 45 to 10 49	
	12.5	12.5	12 43 to 12 57	
Jan. 1	1	12.5	5 42 to 7 7	
	2	11.5	5 42 to 7 7	
	1	9.5	10 58 to 11 24	
	2	11.5	10 58 to 11 24	
	10	10	12 43 to 13 57	
Jan. 2	10.5	10.5	5 17 to 7 2	
	10	10	12 42 to 13 45	
Jan. 3	1	13	5 39 to 6 43	
	2	13	5 39 to 6 43	
	1	10	10 36 to 13 26	
	2	11	10 36 to 13 26	
	3	10	10 36 to 13 26	
	4	10	10 36 to 13 26	
Jan. 8	1	11	5 55 to 8 22	
	2	11	5 55 to 8 22	
	3	11	5 55 to 8 22	
Jan. 12	11	11	6 5 to 6 15	
Jan. 14	1	10	5 58 to 7 2	

COMPARISON STARS *Continued*

Date	Star	Magnitude	Time		Remarks
Jan. 14	2	12	5 <sup>h</sup> 58 <sup>m</sup>	to 7 <sup>h</sup> 2 <sup>m</sup>	
	11.5	11.5	8 43	to 9 58	
	9	9	10 25	to 12 36	
Jan. 16	12	12	5 43	to 7 16	
Jan. 18	12.5	12.5	10 57	to 11 45	
Jan. 19	1	10	5 32	to 7 4	
	2	13	5 32	to 7 4	
	3	13	5 32	to 7 4	
	12	12	8 29	to 9 15	
Jan. 20	10	10	5 46	to 7 2	
	1	9.8	10 37	to 11 58	
	2	10	10 37	to 11 58	
Jan. 21	9	9	10 27	to 10 59	
Jan. 22	1	11	11 56	to 12 28	
	2	12	11 56	to 12 28	
Jan. 24	1	1m br. than <i>Eros</i> . A 12m star fol. it 1.5		6 2	to 6 17
	2	.5m fainter than <i>Eros</i>		9 20	to 9 49
Jan. 25	1	9.8	5 43	to 7 58	
	2	11	5 43	to 7 58	
	3	10.5	5 43	to 7 58	
	4	12	5 43	to 7 58	
Jan. 27	...	13	6 45	to 6 57	
Jan. 28	...	13	6 57	to 7 6	
Feb. 1	...	10	5 52	to 7 16	
Feb. 4	...	10.5	9 33	to 10 52	
Feb. 5	1	9.5	6 5	to 7 17	
	2	8	6 5	to 7 17	
	...	10	10 7	to 10 58	

## BAROMETER AND THERMOMETERS

A copy of the barometer and temperature records follows. These are from the regular records of the observatory.

Date 1900	BAROMETER			ATTACHED THERMOMETER (F.)			EXTERNAL THERMOMETER (F.)		
	9 P. M.	1 A. M.	4 A. M.	9 P. M.	1 A. M.	4 A. M.	9 P. M.	1 A. M.	4 A. M.
Oct. 2	29.01	29.20	29.15	71	73	73	63	65	67
Oct. 3	29.02	29.03	...	77	77	...	73	68	...
Oct. 4	28.90	29.00	29.02	75	76	77	66	68	67
Oct. 8	29.25	29.28	29.27	72	72	73	47	45	43
Oct. 9	29.30	29.30	29.28	72	71	71	52	48	46
Oct. 10	29.19	29.10	29.08	71	71	71	53	51	49
Oct. 11	29.00	28.95	29.08	73	73	72	53	52	52
Oct. 14	29.10	29.10	29.05	73	73	73	61	57	56
Oct. 15	28.93	29.10	...	74	74	...	63	59	...
Oct. 16	29.42	29.35	29.35	71	72	71	39	39	38
Oct. 17	29.10	29.15	29.15	70	71	72	47	41	42
Oct. 18	29.10	29.18	29.17	70	75	75	49	47	47
Oct. 25	29.05	29.12	29.20	78	78	76	64	61	58
Oct. 26	29.22	29.20	29.20	78	78	79	57	53	52
Oct. 27	29.10	29.05	...	75	78	...	57	58	...
Oct. 30	28.92	28.90	28.80	76	73	73	59	58	59
Nov. 1	29.15	29.15	29.20	79	78	79	41	39	39
Nov. 2	29.30	29.35	29.22	78	76	78	50	45	43
Nov. 3	29.00	28.97	28.95	79	81	83	49	49	47
Nov. 4	28.98	29.00	29.05	80	78	77	52	39	34
Nov. 5	29.10	29.10	29.15	78	78	76	42	36	35
Nov. 6	28.90	28.90	...	69	76	...	30	28	...
Nov. 7	28.88	28.90	...	68	76	...	29	25	...
Nov. 8	28.80	28.80	28.80	76	76	76	27	24	22
Nov. 10	29.18	29.00	29.10	75	65	75	30	31	28
Nov. 11	29.10	29.00	...	73	73	...	27	29	...
Nov. 13	29.30	28.95	29.00	76	77	77	19	14 <sup>1</sup>	12
Nov. 15	29.40	29.50	29.50	78	78	78	14	12	14
Nov. 21	28.95	28.80	...	75	78	...	28	30	...
Nov. 22	29.00	29.15	29.20	78	80	80	29	25	22

BAROMETER AND THERMOMETERS *Continued*

Date 1900	BAROMETER			ATTACHED THERMOMETER (F.)			EXTERNAL THERMOMETER (F.)		
	9 P. M.	1 A. M.	1 A. M.	9 P. M.	1 A. M.	1 A. M.	9 P. M.	1 A. M.	1 A. M.
Nov. 23	29.25	29.20	29.20	80	80	80	29	30	31
Nov. 25	29.08	29.05	29.00	72	75	75	28	25	24
Nov. 26	29.00	28.90	28.88	78	78	78	28	28	28
Nov. 27	28.90	29.00	.....	80	80	.....	34	28	.....
Nov. 29	29.05	29.00	29.00	70	72	72	27	28	29
Dec. 1	29.10	29.00	29.00	65	64	68	30	32	29
Dec. 2	29.05	29.00	.....	68	62	.....	32	33	.....
Dec. 3	29.18	29.15	.....	78	78	.....	28	25	.....
Dec. 8	28.90	29.00	.....	75	78	.....	32	23	.....
Dec. 9	29.40	29.35	29.30	70	73	75	9	6	7
Dec. 10	29.20	29.10	.....	74	74	.....	16	17	.....
Dec. 11	29.18	29.10	29.00	77	78	78	12	11	12
Dec. 12	28.78	28.70	.....	80	80	.....	31	27	.....
Dec. 17	29.00	28.95	28.80	68	69	70	31	35	38
Dec. 18	29.05	29.10	29.18	75	75	78	31	32	30
Dec. 19	29.10	29.10	29.10	80	80	81	32	28	26
Dec. 20	28.90	28.80	28.90	82	80	75	33	32	31
Dec. 21	28.45	28.45	28.45	72	72	72	38	40	40
Dec. 24	28.90	28.90	28.90	66	65	62	14	12	16
Dec. 26	29.00	29.00	.....	70	73	.....	19	18	.....
Dec. 28	29.15	29.05	29.00	75	75	75	13	11	13
Dec. 29	28.78	28.70	.....	75	78	.....	22	21	.....
Dec. 30	28.75	28.68	28.65	75	69	60	28	20	18
Dec. 31	29.20	29.30	29.32	75	75	76	5	-10	-11
Jan. 1, 1901	29.40	29.40	.....	68	70	.....	9	4	.....
Jan. 2	29.50	29.50	29.48	76	75	75	0	2	8
Jan. 3	29.20	29.20	.....	73	75	.....	22	19	.....
Jan. 8	29.05	29.10	.....	73	66	.....	22	14	.....
Jan. 12	29.00	28.90	.....	72	78	.....	22	28	.....
Jan. 14	28.88	28.65	28.65	72	75	75	30	30	29
Jan. 16	28.72	.....	.....	73	.....	.....	17	.....	.....
Jan. 18	29.08	.....	.....	75	.....	.....	12	.....	.....
Jan. 19	29.20	29.00	.....	72	70	.....	22	29	.....
Jan. 20	28.80	28.78	28.70	70	72	75	42	39	39
Jan. 21	29.20	29.22	.....	75	78	.....	28	25	.....
Jan. 22	29.10	28.95	28.90	78	78	78	27	27	28
Jan. 24	28.98	29.00	.....	75	75	.....	10	12	.....
Jan. 25	29.05	29.00	29.00	79	80	.....	18	20	28
Jan. 27	28.60	.....	.....	65	.....	.....	16	.....	.....
Jan. 28	28.75	.....	.....	72	.....	.....	8	.....	.....
Feb. 1	28.90	.....	.....	71	.....	.....	4	.....	.....
Feb. 4	29.35	.....	.....	70	.....	.....	7	.....	.....
Feb. 5	29.35	29.25	.....	72	70	.....	0	-5	.....

## EARLIER MICROMETRICAL OBSERVATIONS OF EROS, 1898-99

Previous to the preceding observations of *Eros*, the planet was measured with the large telescope on twenty-seven nights in 1898 and on thirteen nights in 1900. These observations have not been printed and are here published for the first time.

Date 1898-99	Time h m s	Lat. N	Long. W	Planet Star $\Delta^{\circ}$	Apparent $\alpha$	Apparent $\delta$	Parallax Factors		Red. to Apparent	
							$\alpha$	$\delta$	$\alpha$	$\delta$
Sept. 10	12 <sup>h</sup> 1 <sup>m</sup> 28 <sup>s</sup>	1	6	.....	.....	-6 20 26.9	.....	+6.43	.....	+18.2
12	7 19 1	6	.....	.....	.....	.....	.....	.....	.....	.....
12	7 18 40	2	1	.....	.....	-6 20 38.0	.....	+6.58	.....	+18.1
12	8 22 47	2	6	+0 15.62	20 43 38.55	.....	.....	.....	+4.32	.....
12	8 26 11	2	3	.....	.....	-6 20 37.9	.....	+6.59	.....	+18.1
Sept. 12	7 43 41	3	4	-0 4.50	20 42 45.89	.....	.....	.....	+4.31	.....
7	49 4	3	4	+2 43.9	.....	-6 20 50.2	.....	+6.56	.....	+18.1
7	53 39	3	1	-0 4.71	20 42 45.48	.....	.....	-0.140	+4.31	.....
Sept. 19	9 22 51	4	3	-2 25.4	.....	-6 21 23.9	.....	+6.54	.....	+17.7
9	31 46	4	4	-0 39.75	20 37 53.52	.....	.....	+6.105	+4.20	.....
9	45 39	4	2	-2 26.0	.....	-6 21 24.5	.....	+6.57	.....	+17.7
9	49 20	4	2	-0 40.22	20 37 53.05	.....	.....	+0.137	+4.20	.....
Sept. 20	8 18 25	4	4	.....	.....	-6 21 18.3	.....	+6.60	.....	+17.8

EARLIER MICROMETRICAL OBSERVATIONS OF *EROS*, 1898-99—*Continued*

Date—1898-99 90 Time	Comp. Star	No. of Comp.	Planet-Star $\Delta\alpha$ $\Delta\delta$	Apparent $\alpha$	Apparent $\delta$	Parallax Factor $\alpha$ $\delta$	Red. to Apparent $\alpha$ $\delta$
Sept. 20 8 <sup>h</sup> 28 <sup>m</sup> 45 <sup>s</sup>	4	4	-1 <sup>m</sup> 6.43	20 <sup>h</sup> 37 <sup>m</sup> 26 <sup>s</sup> .83	-0.006	.....	+4.19
8 50 24	4	3	-1 6.86	20 37 26.40	+0.036	.....	+4.19
Sept. 21 8 52 1	4	4	+0 11.8	.....	- 6 21 9.2	+6.62	+17.7
9 1 40	4	4	+0 57.49	20 37 1.23	+0.046	.....	+4.18
Sept. 23 7 29 3	4	4	+0 18.52	20 36 22.25	-0.004	+6.58	+17.7
7 33 37	3	3	+0 42.1	20 36 22.09	-0.076	+6.59	+17.7
7 39 39	5	3	+0 18.36	.....	- 6 20 17.9	+6.59	+17.7
Sept. 24 7 39 48	5	5	+1 3.1	20 36 7.50	-0.057	+6.59	+17.7
7 43 37	5	4	+1 3.0	.....	- 6 20 18.0	+6.59	+17.7
7 46 53	5	3	+1 28.4	.....	- 6 19 52.6	+6.58	+17.7
Sept. 25 7 19 33	5	4	-0 9.46	20 35 54.25	-0.090	+6.59	+17.7
7 24 19	5	6	+1 57.8	.....	- 6 19 23.3	+6.59	+17.6
7 27 47	5	3	+1 58.4	20 35 44.84	-0.063	+6.60	+17.6
Sept. 26 7 22 21	5	4	-0 19.00	20 35 44.70	-0.029	+6.58	+17.6
7 33 17	5	6	+2 31.2	20 35 38.58	-0.102	+6.58	+17.6
7 43 50	5	3	-0 25.10	.....	- 6 3 31.3	+0.251	+17.8
Sept. 27 7 50 34	5	2	-0 0.86	20 38 37.97	+0.251	+6.46	+17.8
6 58 31	5	4	-0 21.4	.....	- 6 3 31.8	+0.272	+17.8
7 8 9	5	5	-0 21.9	20 38 38.22	+0.013	+6.57	+17.8
Oct. 10 9 29 15	6	4	+0 28.62	20 39 7.43	- 6 1 51.8	+0.039	+3.92
9 48 13	6	3	+1 18.1	21 37 46.86	+0.155	+6.12	+3.50
Oct. 11 7 17 2	6	5	-0 2.21	.....	- 2 22 4.9	+0.173	+3.50
7 24 53	6	5	-2 1.1	21 37 47.61	+0.231	+6.16	+21.8
7 30 52	6	4	+0 1.46	21 39 48	.....	- 2 13.5	+6.07
Nov. 26 6 30 40	7	4	+0 7.93	21 50 54.26	+0.120	+6.07	+22.5
6 36 6	7	5	+0 40.7	21 56 50.78	+0.219	+6.02	+22.8
6 40 31	7	1	-0 7.52	22 4 50.3	+0.151	+5.92	+22.1
Nov. 27 8 13 56	8	5	+0 21.1	.....	- 0 18.8	+0.172	+3.46
8 19 15	8	1	-0 36.0	.....	.....	+0.279	+3.47
Dec. 3 6 7 32	9	4	+1 21.1	22 19 34.16	+0.192	+5.83	+24.0
6 12 45	9	4	-0 32.3	.....	+ 0 53 10.9	+5.41	+ 6.4
Dec. 6 6 46 58	10	5	+0 5.31	23 35 30.62	+0.374	+5.44	+0.51
6 54 22	10	5	-0 34.4	23 51 12.72	+0.340	+5.24	+0.55
Dec. 10 6 0 41	11	5	+3 19.1	23 51 14.12	+0.355	+5.10	+0.57
6 6 56	11	5	+0 5.51	.....	+0.342	+5.10	+ 6.6
6 13 28	11	4	-0 13.25	.....	+0.358	+5.04	+0.61
Dec. 13 7 9 3	12	4	-0 36.0	.....	+0.343	.....	+ 5.7
7 13 18	12	4	+0 6.21	.....	.....	.....	+ 6.9
7 17 32	12	3	-0 32.3	.....	.....	.....	.....
Dec. 17 6 10 49	13	3	+0 5.31	.....	.....	.....	.....
6 13 54	13	3	-0 34.4	.....	.....	.....	.....
Jan. 18 7 22 50	14	4	+3 19.1	.....	.....	.....	.....
7 29 24	14	5	+0 5.51	.....	.....	.....	.....
7 34 52	14	4	+3 26.1	.....	.....	.....	.....
Jan. 24 6 52 31	15	4	+0 10.05	.....	.....	.....	.....
6 59 3	15	5	-2 59.6	.....	.....	.....	.....
7 5 9	15	3	+0 11.42	.....	.....	.....	.....
Jan. 31 6 43 7	16	4	-0 15.07	.....	.....	.....	.....
6 50 16	16	6	+0 9.4	.....	.....	.....	.....
6 57 23	16	5	-0 13.45	.....	.....	.....	.....
Feb. 1 6 43 23	17	4	+0 0.51	.....	.....	.....	.....
6 48 40	17	4	+2 1.7	.....	.....	.....	.....
6 56 22	17	4	+2 06.4	.....	.....	.....	.....
Feb. 7 6 54 44	18	4	-4 28.8	.....	.....	.....	.....
7 14 20	18	4	-0 36.57	.....	.....	.....	.....
Feb. 12 6 52 42	19	4	-0 5.09	.....	.....	.....	.....
6 58 27	19	5	-1 20.3	.....	.....	.....	.....
7 4 11	19	4	-0 3.66	.....	.....	.....	.....

DIRECT MEASURES OF  $\Delta\alpha$ 

As many of the differences of right ascension were measured direct with the micrometer and afterwards reduced to time, it is thought best to tabulate the original measures themselves, and they are given below.

## MEASURED DIFFERENCES OF RIGHT ASCENSION

Date 1888	90th Meridian Time	$\Delta\alpha$ in Arc Planet-Star	Date 1888	90th Meridian Time	$\Delta\alpha$ in Arc Planet-Star	Date 1888-89	90th Meridian Time	$\Delta\alpha$ in Arc Planet-Star
Sept. 10	12 7 <sup>m</sup> 19 <sup>s</sup>	+152.8	Sept. 26	7 <sup>m</sup> 33 <sup>m</sup> 17 <sup>s</sup>	-281.1	Dec. 10	6 <sup>m</sup> 13 <sup>m</sup> 28 <sup>s</sup>	-198.7
Sept. 11	8 22 47	+225.7	Sept. 26	7 50 34	-283.2	Dec. 13	7 13 18	+ 93.2
Sept. 12	7 43 41	64.1	Sept. 27	7 8 9	-374.1	Dec. 17	6 10 49	+ 79.7
Sept. 12	7 53 39	70.2	Oct. 10	9 34 46	- 12.9	Jan. 18	7 29 24	+ 82.8
Sept. 19	9 31 46	-532.6	Oct. 10	9 48 13	- 9.1	Jan. 24	6 52 31	+148.7
Sept. 19	9 49 20	-599.4	Oct. 11	7 17 2	+186.6	Jan. 24	7 5 9	+169.1
Sept. 20	8 28 43	-990.4	Oct. 11	7 30 52	+190.9	Jan. 31	6 43 7	-222.1
Sept. 20	8 50 24	-997.1	Nov. 26	6 30 40	- 31.1	Jan. 31	6 57 23	-198.3
Sept. 21	9 1 40	+857.2	Nov. 26	6 40 31	-21.9	Feb. 1	6 43 23	+ 7.5
Sept. 21	7 29 3	+276.1	Nov. 27	8 13 56	+118.9	Feb. 7	7 14 20	-536.5
Sept. 23	7 39 39	+273.7	Dec. 3	6 7 32	-112.8	Feb. 12	6 52 42	- 74.2
Sept. 24	7 43 37	+ 41.3	Dec. 6	6 46 58	-236.1	Feb. 12	7 4 11	- 53.4
Sept. 25	7 24 19	-141.0	Dec. 10	6 0 41	-214.3			

## MEAN PLACES OF COMPARISON STARS FOR 1898-99

Star	R. A.	Declination	Authority
1	20 44 11.88	- 6 20 26.6	R. H. Tucker, Lick Observatory M.C.
2	20 43 18.61	- 6 18 45.7	R. H. Tucker, Lick Observatory M.C.
3	20 42 45.88	- 6 23 52.2	R. H. Tucker, Lick Observatory M.C.
4	20 38 49.07	- 6 19 16.2	R. H. Tucker, Lick Observatory M.C.
5	20 35 59.56	- 6 21 38.7	R. H. Tucker, Lick Observatory M.C.
6	20 38 34.89	- 6 3 27.7	Schj. 8242
7	21 37 45.57	- 2 20 25.5	$\frac{1}{2}$ (München I 29286 + München II 11916)
8	21 39 36.7	- 2 14.5	Compared with S.D. -25623
9	21 50 58.28	- 1 28 26.8	$\frac{1}{3}$ (Copeland and Borgen, Göttingen Cat. 6038+6039)
10	21 56 31.58	- 0 53 29.2	10m. Compared with $\frac{1}{3}$ (Copeland and Borgen, Göttingen Cat. 6076+6077+6078)
11	22 5 1.1	- 0 22.0	B.D. -0°4316
12			9.75m star
13	22 19 25.37	+ 0 53 21.3	12m. Compared with $\pi$ <i>Aquarii</i>
14	23 35 24.60	+ 7 28 10.2	Leipzig A.G.C. 11727
15	23 51 2.12	+ 8 58 28.8	9.6m. Compared with Leipzig A.G.C. 11836
16	0 10 46.0	+10 35.1	B.D. +10°20
17	0 12 59.69	+10 48 9.0	Compared with Leipzig A.G.C., No. 69
18	0 27 48	+12 7.4±	Approximate from ephemeris
19	0 44 41.87	+13 31 8.9	9.7m. Compared with W.B. 0°754

## MICROMETRICAL OBSERVATIONS OF EROS IN 1900

Date 1900	Comp. Star	Planet-Star $\Delta\alpha$	Apparent $\alpha$	Apparent $\delta$	Parallax Factor $\alpha$	Red. to Apparent $\alpha$	Red. to Apparent $\delta$
July 30	14 <sup>b</sup> 6 <sup>m</sup> 35 <sup>s</sup> 2	+0 8.6	.....	.....	+3.64	.....	+12.7
	14 13 43 3	+0 7.87	.....	.....	-0.312	.....	.....
	14 23 51 1	-1 12.3	.....	+22 <sup>m</sup> 16.6	.....	+3.52	+12.7
	14 35 19 1	-1 21.6	.....	+22 16.4	.....	+3.45	+12.7
Aug. 1	13 20 25 2	+4 59.4	.....	+22 58.5	.....	+3.89	+12.6
	13 31 42 2	-0 29.92	1 <sup>b</sup> 38 <sup>m</sup> 38.8	.....	-0.356	.....	+3.47
	13 41 27 2	+5 18.3	.....	+22 58.8	.....	+3.72	.....
Aug. 4	14 16 36 3	+0 38.5	.....	+24 0.1	.....	+3.29	+12.5
	14 25 9 3	-0 21.34	1 43 20.62	.....	0.264	.....	+3.56
	14 33 23 3	+0 52.7	.....	+24 0.4	.....	+3.17	+12.5
	14 44 59 4	+2 51.3	.....	+24 19 32.5	.....	+3.08	+12.5
Aug. 5	14 37 14 4	-0 0.19	1 11 53.85	.....	-0.227	.....	+3.60
	14 44 59 4	+3 3.1	.....	+24 19 44.3	.....	+3.00	+12.5
	14 51 46 4	+1 5.9	.....	.....	.....	+2.85	+12.4
Aug. 6	15 13 51 5	+0 17.27	.....	.....	-0.163	.....	+3.67
	15 18 9 5	-1 14.1	.....	.....	.....	+2.80	+12.4
	15 23 9 5	+0 35.4	.....	.....	.....	+1.97	+4.10
Aug. 20	15 40 6 5	+0 0.65	.....	.....	-0.042	.....	+12.2
	15 51 19 6	+0 48.9	.....	+20 30.8	.....	+0.45	+4.10
Aug. 27	15 58 6 7	+1 0.9	.....	.....	.....	+1.00	+12.0
	16 2 34 7	-0 3.90	.....	.....	+0.040	.....	+4.32
	16 6 50 7	+1 8.9	.....	.....	.....	+1.61	+12.0
Sept. 3	13 2 21 8	+1 1.0	.....	.....	.....	+1.90	+11.7
	13 10 52 8.5	-1 0.4	.....	.....	.....	.....	.....

MICROMETRICAL OBSERVATIONS OF *EROS* IN 1900—Continued

Date—1900 30 Time	Comp. Star No.	Comp.	Planet-Star $\Delta\alpha$ $\Delta\delta$	Apparent $\alpha$	Apparent $\delta$	Parallax Factors $\alpha$ $\delta$	Red. to Apparent $\alpha$ $\delta$
Sept. 3 13 17 2	8.5	4	-0 <sup>m</sup> 4 <sup>s</sup> 28	2 <sup>h</sup> 24 <sup>m</sup> 26 <sup>s</sup> 54	+34° 30' 47.4	-0.280	+4.61
	8.5	4	-0 <sup>m</sup> 49 <sup>s</sup> 13		+34 54 39.9		
Sept. 4 15 16 12	9	4	-1 22.9			+1.15	+11.7
	15 20 47	9	-0 1.66	2 25 39.64		-0.266	+4.65
	15 24 49	9	-1 15.0		+34 54 47.8	+1.15	+11.7
Sept. 10 13 7 30	10	5	+2 13.1	2 31 50.80	+37 6 57.1	+1.32	+11.6
	13 15 54	10	-0 16.97			-0.250	+4.86
	13 23 32	10	+2 29.2		+37 7 13.2	+1.19	+11.6
Sept. 11 13 26 7	11	4	-1 31.7			+1.10	+11.4
	14 8 46	11	+0 34.81	2 32 49.66		-0.260	+4.94
	14 25 49	11	-0 35.2		+38 17 51.3	+0.80	+11.4
Sept. 13 16 11 5	12	5	-1 34.1 <sup>1</sup>			+0.78	+11.5
	16 30 35	12	-0 18.63	2 34 43.05		+0.198	+5.02
	16 35 0	13	-0 13.54	2 34 43.17		+0.205	+5.02
	16 41 48	14	+0 6.37	2 34 43.47		+0.220	+5.02
	16 46 37	13	-1 42.5 <sup>1</sup>		+38 18 34.5	+1.00	+11.5
Sept. 19 12 2 18	15	5	+1 9.2		+40 30 42.1	+1.21	+11.7
	12 15 35	15	-0 19.20	2 39 14.83		-0.330	+5.30
	12 26 5	15	-1 32.4		+40 31 5.3	+0.95	+11.7
Sept. 27 13 6 25	16	4	+2 38.4		+43 35.8	0.00	+11.9
	13 16 53	16	-0 46.19	2 42 33.6		-0.133	+5.64
	13 31 24	17	-0 5.6			-0.12	+11.9
	13 37 52	17	+0 9.76			-0.082	+5.64
	13 48 47	17	+0 10.8			-0.15	+11.9

## MEASURED DIFFERENCES OF RIGHT ASCENSION

Date—1900	90th Meridian Time	$\Delta\alpha$ in Arc Planet-Star	Date—1900	90th Meridian Time	$\Delta\alpha$ in Arc Planet-Star	Date—1900	90th Meridian Time	$\Delta\alpha$ in Arc Planet-Star
July 30.....	14 <sup>h</sup> 13 <sup>m</sup> 43 <sup>s</sup>	+109.2	Aug. 27....	16 <sup>h</sup> 2 <sup>m</sup> 34 <sup>s</sup>	— 44.6	Sept. 13....	16 <sup>h</sup> 35 <sup>m</sup> 0 <sup>s</sup>	—159.3
Aug. 1.....	13 31 42	—413.0	Sept. 4....	15 20 47	— 20.4	Sept. 13....	16 41 48	+ 74.9
Aug. 4.....	14 25 9	—233.2	Sept. 10....	13 15 54	—205.4	Sept. 19....	12 15 35	—218.3
Aug. 6.....	15 18 9	+235.3	Sept. 11....	14 8 46	+414.4	Sept. 27....	13 37 52	+106.0
Aug. 20....	15 43 40	+ 8.4	Sept. 13....	16 30 35	—219.2	.....	.....	.....

MEAN PLACES OF COMPARISON STARS, 1900.0

Stars	R. A.	Declination	Authority
1	1 <sup>h</sup> 36 <sup>m</sup> 49.4	+22° 17.6	B.D. +22°261
2	1 39 5.2	+22 53.3	B.D. +22°265
3	1 43 38.4	+23 59.3	B.D. +23°242
4	1 44 50.44	+24 16 28.7	12m. Compared with Berlin A.G.C. 542
5	.....	.....	12.3m star
6	2 6 43.1	+29 29.8	12m. Compared with B.D. 29°373
7	2 11 48.8	+31 56.6	B.D. +31°408
8	2 25 3.88	+34 29 15.2	Leiden A.G.C. 933
8 <sub>2</sub>	2 24 26.21	+34 31 24.8	10.5m. Compared with Leiden A.G.C. 933
9	2 25 36.65	+34 55 51.1	11m. Compared with Leiden A.G.C. 935
10	2 32 2.91	+37 4 32.4	Lund A.G.C. 1291
11	2 32 9.91	+37 31 9.3	Lund A.G.C. 1295
12	2 34 56.66	+38 19 13.7	10.2m. Compared with 14 = <i>d</i>
13	2 34 51.69	+38 20 5.5	10.2m. Compared with 14 = <i>c</i>
14	2 34 32.08	+38 19 55.3	10.0m. Compared with Lund A.G.C. 1273 = <i>a</i>
15	2 39 28.74	+40 29 21.2	Bonn A.G.C. 2351.
16	2 43 14.2	+43 33.0	B.D. +43.585.
17	.....	.....	10.5m star

<sup>1</sup> One of these is 1r (9'67) in error — probably the last one.

## MICROMETRICAL MEASURES OF COMPARISON STARS

## COMPARISON STAR FOR 1898, NOV. 27

Compared with S.D. 2°5623

13m star precedes 0' 25'43 (7) = 1'69

13m star north 5' 24'47 (4)

## COMPARISON STAR FOR 1898, DEC. 6

Compared with  $\frac{1}{2}$  (Copeland & Börgen, Göttingen

Cat. 6076 + 6077 + 6078)

10m star precedes 0<sup>m</sup> 9'49 (5)

10m star south 41. 36'6 (4)

## COMPARISON STAR FOR 1898, DEC. 17

Compared with  $\pi$  *Aquarii*

12m star precedes 9' 40'71 (4) = 38'72 (using an intermediate star)

12m star north 1' 46'19 (4)

Direct  $\Delta\alpha$  by transit gave  $\Delta\alpha = 38'37$  (18)

## COMPARISON STAR FOR 1899, FEB. 1

Compared with Leipzig A.G.C. 69

12m star preceding 2' 17'07 (4) = 9'30

12m star north 9' 22'8 (4) (using several intermediate stars)

## COMPARISON STAR FOR 1899, FEB. 12

Compared with W.B. 0°754

9.7m star precedes 1<sup>m</sup> 13'72 (10)

9.7m star south 1' 0'56 (3)

## COMPARISON STAR FOR 1899, JAN. 24

Compared with Leipzig A.G.C. No. 11836

9.6m star precedes 2<sup>m</sup> 36'90 (8)

9.6m star south 0' 50'19 (3)

## COMPARISON STAR FOR 1899, JAN. 31

Compared with B.D.M. + 10°23

9.5m star precedes 1<sup>m</sup> 24'25 (8)

9.5m star south 3' 54'06 (3)

## COMPARISON STAR FOR 1900, AUG. 5

Compared with Berlin A.G.C. 542

12m follows 0<sup>m</sup> 36'68 (18)

12m north 0' 52'08 (3)

## COMPARISON STAR FOR 1900, AUG. 20

Compared with B.D. + 29°373

12m star precedes 0<sup>m</sup> 24'33 (16)

12m star south 2' 45'50 (4)

## COMPARISON STAR FOR 1900, SEPT. 3

Compared with Leiden A.G.C. 933

10m star precedes 0<sup>m</sup> 37'67 (16)

10m star north 2' 9'45 (4)

## COMPARISON STAR FOR 1900, SEPT. 4

12m star follows 0<sup>m</sup> 29'98 (14)

12m star south 1' 27'56 (4)

## COMPARISON STARS FOR 1900, SEPT. 13

Compared with Lund A.G.C. 1273

Star *a**a* follows 1273 3<sup>m</sup> 49'83 (6)*a* north 1' 41'22 (2)Now compare *b*, *c*, *d* with *a*:*b* follows *a* 0<sup>m</sup> 11'76*b* north of *a* 1' 2'38*c* follows *a* 0<sup>m</sup> 19'61*c* north 0' 10'17*d* follows *a* 0<sup>m</sup> 24'58*d* south 0' 30'97

These  $\Delta\alpha$  and  $\Delta\delta$  with respect to *a* are from the following position angles and distances:

*a* and *b* 65°56 (4) distance 151'94 (4 single dist.)*b* and *c* 119.53 (4) 106.94 (4 " " )*c* and *d* 131.53 (4) 78.13 (4 " " )

The star *b* of the 10.3m was not used in the observations of *Eros*.

In the observations of 1900, September 10, the planet was referred to the Lund star through a 10.5m star.

10.5m star precedes A.G.C. 1291 by 208'00 (6 obs.) = 0<sup>m</sup> 17'38

10.5m north A.G.C. 1291 by 0' 54'10 (5 obs.)

Place of 10.5m star; 1900.0 2<sup>h</sup> 31<sup>m</sup> 45'54 + 37° 5' 26'2

In the first two measures of 1900, July 30, the planet was referred to an unknown nebula.

I wish to express my thanks to Professor R. H. Tucker, of the Lick Observatory, for special observations of some of the comparison stars. I am also very greatly obliged to Professor William H. Hussey, of the Lick Observatory, for supplying me with star places from the various star catalogues in the library of the Lick Observatory not available here, and also for a manuscript copy of his accurate ephemeris of *Eros* for the identification of comparison stars.

I am also indebted to Professor S. J. Brown, of the U. S. Naval Observatory, for catalogue places of some of the stars.

ESTIMATIONS OF THE BRIGHTNESS OF *EROS*

The remarkable variations in the light of *Eros* which are shown to have occurred during the apparition of 1900-1901 have added a much greater interest to the planet. The cause of these light changes is yet a mystery, though several more or less plausible explanations have been brought forward. During the observations made here this peculiarity was not known, having developed later on. No special observations were therefore made of its brightness. I find, however, in going over the measures with the 40-inch, that *Eros* was carefully compared in brightness with various stars near it, not only in the measures of 1900, but also in 1898 within a short time of the discovery of the planet. These stars can readily be identified in the sky and their magnitudes determined, from which an accurate value can be had of the light of *Eros* on some eight or nine nights in 1898 and on over thirty nights in 1900. Since, in the great majority of cases, the brightness of *Eros* differed only a fraction of a magnitude from that of the star, the comparisons will be very accurate and should be very important in connection with the singular variation of the light of the planet.

That these observations may be made available, I have collected them here with all the data required for the identification of the comparison stars when used with an accurate ephemeris of *Eros*.

The stars referred to are those used at the time of observation for the position of the planet, if not otherwise stated.

The times herein contained are 90th meridian time, which is  $6^h 0^m 0^s$  slow of Greenwich mean time.

## 1898

September 11: At  $8^h 11^m 45^s$  *Eros* was  $1.14$  north of a small star. A few seconds before this it had passed within about  $0.6$  of the star — the two appearing for a few moments as a beautiful double star. *Eros* was  $0.2m$  less than the star.

On September 12 the position of this star was measured with reference to the comparison star of September 11.  $\Delta\alpha 4^\circ 1'15''$  (6)  $\Delta\delta 2^\circ 11'55''$  (3) south following the comparison star of September 11.

September 20,  $9^h 0^m$ : *Eros* estimated at  $11.8m$ . There are two stars, one south following *Eros*  $2\frac{1}{2}'$ , the other north following  $3'$ . These are of about equal magnitude. *Eros* is  $0.1m$  less than either star.

September 21: At  $9^h 1^m 40^s$  *Eros* followed an  $11m$  star by  $17.05$  (4) and was  $\frac{1}{2}' \pm$  north of the star. The planet was  $0.5m$  less than this star. A similar star was about  $\frac{1}{2}'$  north preceding *Eros*. *Eros* was also  $0.5m$  less than this star.

September 24: At  $7^h 40^m$  *Eros* is  $0.2m$  less than a small star that is close south following the  $7.7m$  comparison star. The estimated magnitude of *Eros* was  $11.5m$ .

September 26,  $8^h 11^m$ : *Eros* is  $7'$  or  $8'$  south of a small double star [P.A.  $271.5$  (4) distance  $3.75$  (4)].  $1'$  south of these is a small star exactly the same magnitude as *Eros*. There are two somewhat brighter stars  $2'$  or more south of this star.

October 11: At  $7^h 25^m$  *Eros* is  $12.8$  south of a small star and follows it  $1\frac{1}{2}' \pm$ . *Eros* is  $0.1m$  brighter than this star.

December 10,  $6^h 17^m$ :  $2\frac{1}{2}'$  preceding *Eros* is a small star. The planet is exactly the same magnitude as this star.

## 1899

January 31,  $7^h 0^m$ : Estimated magnitude =  $11$ . It is bright and easy. There are two stars  $3'$  or  $4'$  preceding. It is brighter than either of these stars.

February 12,  $7^h 10^m$ :  $2\frac{1}{2}'$  following the comparison star are two small stars. *Eros* is exactly the same brightness as these.

## 1900

August 4,  $14^h 35^m$ : *Eros* about  $12.2m$ .

August 6,  $15^h 18^m$ : *Eros*  $0.1m$  brighter than the comparison star. The planet is estimated to be  $12m$ .

August 7,  $13^h 50^m$ : Estimated at  $12.2m$ . There is a star of the same brightness as the planet preceding  $4'$  and  $1\frac{1}{2}'$  north.

August 20,  $15^h 55^m$ : There are two stars marked  $12.1m$   $1'$  and  $2'$  south preceding the planet. *Eros* is  $0.1m$  brighter than these.

August 27,  $16^h 10^m$ : There is an  $11.5m$  star  $1\frac{1}{2}'$  following the comparison star which is exactly the same brightness as *Eros*.

- September 3, 13<sup>h</sup> 25<sup>m</sup>: Estimated magnitude, 11.5m. *Eros* is 0.5m or 0.7m less than the 10.5m comparison star.
- September 10, 13<sup>h</sup> 20<sup>m</sup>: Estimated magnitude, 11m. Small comparison star estimated at 10.5m
- September 13, 14<sup>h</sup> 25<sup>m</sup>: Estimated at 10.7m. The estimations for the stars near were  $a = 10m$ ,  $b = 10.2m$ ,  $c = 10m$ ,  $d = 10m$ .
- September 19, 12<sup>h</sup> 30<sup>m</sup>: There is an 11m star 2' preceding and  $\frac{1}{2}' \pm$  north, exactly the same magnitude as *Eros*.
- September 27, 13<sup>h</sup> 50<sup>m</sup>: *Eros* and the 10.5m comparison star are of the same brightness—possibly *Eros* is very slightly the brighter.
- October 2, 8<sup>h</sup> 40<sup>m</sup>: *Eros* 0.5m brighter than star 1.
- October 4, 12<sup>h</sup> 25<sup>m</sup>: Estimated at 10m. It is 0.3m brighter than the comparison star.
- October 9, 8<sup>h</sup> 5<sup>m</sup>: Estimated at 10m. Star 1 is 12.2m; star 2 is 12m; star 3 is 12.5m. Same date, 16<sup>h</sup> 20<sup>m</sup>: *Eros* 0.7m less than star 1. Same date, 16<sup>h</sup> 40<sup>m</sup>: A little less than star 1, perhaps 0.5m.
- October 25, 18<sup>h</sup> 2<sup>m</sup>: *Eros* still easily visible on the bright sky. The comparison stars have all faded out.
- November 1, 17<sup>h</sup> 50<sup>m</sup>: Estimated at 9.8m. It is exactly the same brightness as star 1 and 0.2m brighter than star 2.
- November 2, 12<sup>h</sup> 50<sup>m</sup>: It is from 0.1m to 0.2m brighter than star 2 and 0.3m brighter than star 1.
- November 11, 6<sup>h</sup> 50<sup>m</sup>: It is 0.2m brighter than the comparison star. Same date, 8<sup>h</sup> 20<sup>m</sup>: It is 0.3m brighter than the comparison star. The comparison star estimated at 9.7m.
- November 13, 18<sup>h</sup> 10<sup>m</sup>: It is 0.2m brighter than star 2.
- November 22, 8<sup>h</sup> 50<sup>m</sup>: It is 0.25m brighter than star 2 and about 0.7m brighter than star 1. It is much easier than star 2.
- November 23, 10<sup>h</sup> 0<sup>m</sup>: It is 0.5m  $\pm$  brighter than the comparison star.
- November 25, 18<sup>h</sup> 0<sup>m</sup>: It is 0.5m brighter than either star 3 or star 4, which are equal.
- December 5, 9<sup>h</sup> 30<sup>m</sup>: It is 0.5m or 0.7m brighter than star 1. Same date, 14<sup>h</sup> 0<sup>m</sup>: It is 0.5m brighter than the comparison star.
- December 8, 7<sup>h</sup> 10<sup>m</sup>: It is nearly 1m brighter than the comparison star. Same date, 14<sup>h</sup> 20<sup>m</sup>: It is from 0.5m to 0.7m brighter than the comparison star.
- December 12, 6<sup>h</sup> 0<sup>m</sup>: It is 1m brighter than star 2. It is 0.7m or 0.8m less than star 1.
- December 18, 12<sup>h</sup> 52<sup>m</sup>: It is 0.3m brighter than the comparison star. The star estimated at 8.8m.
- December 29, 5<sup>h</sup> 40<sup>m</sup>: It is the same magnitude as the comparison star.
- December 31, 6<sup>h</sup> 50<sup>m</sup>: It is the same brightness as the comparison star possibly very slightly brighter.

## 1901

- January 14, 10<sup>h</sup> 25<sup>m</sup>: It is from 0.5m to 0.7m brighter than the comparison star.
- January 19, 6<sup>h</sup> 10<sup>m</sup>: It is 0.7m brighter than star 1.
- January 21, 10<sup>h</sup> 30<sup>m</sup>: It is less than the comparison star. Same date, 11<sup>h</sup> 0<sup>m</sup>: It is from 0.1m to 0.2m less than the comparison star, and is slightly yellowish.
- January 24, 6<sup>h</sup> 10<sup>m</sup>: It is 1m less than the comparison star. Same date, 9<sup>h</sup> 50<sup>m</sup>: It is 0.5m brighter than the comparison star.
- January 25, 7<sup>h</sup> 10<sup>m</sup>: It is 0.1m brighter than star 1.
- February 5, 10<sup>h</sup> 50<sup>m</sup>: It is 0.2m brighter than the comparison star, which is about 10m.

METHODS OF TREATING PROBLEMS IN CELESTIAL  
MECHANICS



# ON CERTAIN RIGOROUS METHODS OF TREATING PROBLEMS IN CELESTIAL MECHANICS

F. R. MOULTON

## §1. INTRODUCTION

MATHEMATICAL science was not sufficiently developed to enable the founders of celestial mechanics to prove in many cases the validity of the methods which they found it necessary to employ. Doubtless, too, mathematicians of a century and more ago did not realize so keenly as they do at present the necessity of relying only upon those processes which have been proved to be legitimate. In both pure mathematics and astronomy many conclusions were drawn which have since been shown to be erroneous or which still lack proof. Celestial mechanics has been filled with series, comparatively few of which have been proved to be convergent. It may be said by way of excuse, however, that the problems which astronomers have been called upon to solve have been almost invariably of great difficulty, and their powers have been sufficiently taxed to obtain formal solutions which would agree with observations.

The critical attitude respecting the convergence of series may safely be said to date from the researches of Abel on the hypergeometric series in 1826, and to have received its greatest early impulse from the researches of Cauchy in the theory of functions of complex variables. The latter half of the nineteenth century witnessed a complete re-examination of the foundations of analysis, the correction of numerous errors, and the introduction of an entirely new spirit of rigor.

It is worthy of remark that many mathematical processes, especially those used in integrating total differential equations, have had their origin in attempts to solve astronomical problems. After having been started they have been developed in the realm of pure mathematics far beyond their astronomical applications; and, with the exception of the epoch-making researches of Poincaré (1892-98), the improvements in the methods of celestial mechanics and the standard of rigor maintained have in no way kept pace with these developments. The question is pertinent whether those interested in celestial mechanics should not henceforth adhere more nearly, if not entirely, to methods which are known to be rigorous.

In this paper it is proposed to show how some of the important problems of celestial mechanics may be treated by processes which are proved to be valid at least within prescribed limits. These problems will depend upon the integration of total differential equations in series, and the central question will relate to the convergency of the series. It will be shown how certain of the standard methods are valid for not too great values of the time, and how other problems can be solved. It will be shown that, if the initial conditions are known, it is possible to construct series which will represent the co-ordinates of the moon with any desired degree of accuracy for any desired length of time, provided it does not go outside of an arbitrary anchor ring inclosing its present orbit, and that the number of terms which will be sufficient can be determined in advance; it will be shown that the usual method of computing absolute perturbations has a certain realm of validity, and that the terms of different orders have simple physical interpretations; it will be shown how the secular terms of the first order can be avoided in the mutual perturbations of the planets, giving results in some respects similar to those obtained by the methods of Lagrange, but in others essentially different; and it will be shown that the higher terms in Hill's celebrated lunar theory can be defined in such a manner that the theory as a whole has a positive realm of validity.

§2. POWER SERIES IN THE TIME<sup>1</sup>

The first and simplest method of integrating differential equations of the type occurring in considering the motions of the planets and satellites is to develop the solutions as power series in the independent variable. The usefulness of this method in astronomical problems is quite limited because of the small value of the time for which the series converge. As this is the best-known method of integrating differential equations, a mere outline of the steps and the proof of their validity will be sufficient.

The differential equations of motion of  $k$  mutually attracting spheres may be written in the form

$$\frac{dx_i}{dt} = X_i(x_1, \dots, x_n, t) \quad (i=1, \dots, n), \quad (n=6k), \quad (1)$$

where the  $X_i$  are all analytic functions of  $x_1, \dots, x_n$  and  $t$ . If the bodies are not spheres, but of some known form, as oblate spheroids, the number of differential equations is doubled for a given number of bodies. If the bodies are spheres, and if the  $x_i$  are the rectangular co-ordinates and the components of velocity, the right members of (1) will not involve the time explicitly. There is no loss in generality in supposing that at the origin of time  $t=0$ ,  $x_i=0$  ( $i=1, \dots, n$ ); for, if it were not so, a convenient transformation of variables would secure these conditions. In all astronomical problems the  $X_i$  are all regular for  $x_i=0$  ( $i=1, \dots, n$ ),  $t=0$ .

To find the solutions, suppose the  $X_i$  are developed as power series in  $x_1, \dots, x_n, t$  as

$$\frac{dx_i}{dt} = \sum_{j_1, \dots, j_n, k=0}^{\infty} a_{ij_1 \dots j_n k}^{(i)} x_1^{j_1} x_2^{j_2} \dots x_n^{j_n} t^k \quad (i=1, \dots, n), \quad (2)$$

expansions which, under the conditions stated, converge for sufficiently small  $x_1, \dots, x_n$  and  $t$ . The solutions are to have the form

$$x_i = \sum_{j=1}^{\infty} c_j^{(i)} t^j \quad (i=1, \dots, n). \quad (3)$$

If equations (3) are substituted in (2) and the coefficients of corresponding powers of  $t$  equated in the two members, it will be found that all of the  $c_j^{(i)}$  can be determined uniquely in the order of increasing values of  $j$ .

It only remains to prove that the series (3) have positive radii of convergency. This is done by using a comparison system of differential equations

$$\frac{dy_i}{dt} = Y_i(y_1, \dots, y_n, t) \quad (i=1, \dots, n), \quad (1')$$

where the  $Y_i$  fulfil all the conditions imposed upon the  $X_i$ , and the additional ones that every coefficient of their expansions shall be real and positive and greater than the modulus of the corresponding coefficient in the expansions of the  $X_i$ . Suppose further that the solutions of (1') are

$$y_i = \sum_{j=1}^{\infty} b_j^{(i)} t^j \quad (i=1, \dots, n), \quad (3')$$

where the coefficients  $b_j^{(i)}$  are determined as the  $c_j^{(i)}$  were. It is easily shown, then, that every  $b_j^{(i)}$  is real and positive and greater than the modulus of the corresponding  $c_j^{(i)}$ . Consequently, (3) converge for at least as large values of  $t$  as (3') do.

All of the conditions imposed upon (1') can be fulfilled by equations of the form<sup>2</sup>

$$\frac{dy_i}{dt} = \frac{C}{[1 - \alpha_1 y_1 - \dots - \alpha_n y_n][1 - \beta t]}, \quad (1'')$$

<sup>1</sup> The first proof of the convergence of the series obtained by this method was given by Laplace in his *Compendium de Mécanique* (Paris, 1842), and *lected Works*, 1st series, Vol. VII.

<sup>2</sup> See JORDAN, *Cours d'analyse*, Vol. I, p. 195.

where  $C, a, \beta$  are real positive constants. Integrating these equations, determining the constants of integration by the condition that  $y_i = 0$  for  $t = 0$  and solving for  $y_i$ , it is found that

$$y_i = 1 - \sqrt{1 + \frac{2naC}{\beta} \log(1 - \beta t)} . \quad (3'')$$

It follows from this equation that the  $y_i$  can be expanded in converging power series in  $t$  if

$$\begin{aligned} |t| &< \frac{1}{\beta} , \\ |t| &< \frac{1}{\beta} \left( 1 - e^{-\frac{\beta}{2naC}} \right) , \end{aligned} \quad (4)$$

inequalities which can always be fulfilled by finite values of  $t$  for finite values of  $a, \beta$ , and  $C$ . Consequently the series (3) converge for sufficiently small values of the time.

A defect of the method just outlined is that it does not give the true radius of convergence of the series. Picard has shown,<sup>3</sup> indeed, that the limit imposed on  $t$  by the inequalities (4) is always smaller than the true radius of convergence.

### §3. APPLICATION OF MITTAG-LEFFLER'S GENERALIZED POWER SERIES

As has been remarked, the series (3) in most practical problems converge for only a short interval of time. Since the singularities of the right members of (1) are isolated, the singularities of (3) are also isolated; hence equations (3) define the values of the  $x_i$  for all values of  $t$  by the Weierstrassian continuation of power series. But to continue power series by the method of Weierstrass, it is necessary to know the location of the singularities, the very thing that is unknown when the series is defined by non-linear differential equations. In addition to this, the work of actually continuing power series is so great as seriously to impair the value of the method even when the positions of the singular points are known.

Part of these difficulties have been overcome by Mittag-Leffler<sup>4</sup> in his researches on methods of representing analytic functions in extended regions of the complex plane by generalizations of power series.

For simplicity let any of equations (3) be written in the form

$$x = \sum_{i=1}^{\infty} a_i t^i , \quad (5)$$

where now  $t$  is a complex variable. Suppose this series converges so long as  $|t| < t_0$ . Mittag-Leffler has shown in *loc. cit.* how to construct a series of series out of  $t$  and the coefficients  $a_i$  associated with the point  $t = 0$  which shall be uniformly convergent in a widely extended region which he called a *star*.

There is a star  $A_n$  associated with the coefficients  $a_i$  for every positive integer  $n$ , which is defined as follows<sup>5</sup>: With  $t = 0$  as the origin draw any vector. The positive quantity  $r$  may be chosen so small that if the length of the vector is taken as  $(n-1)r$ , then every circle whose radius is  $r$  and whose center is on the vector will contain none but regular points in its interior or on its boundary. Let  $\rho$  be the upper limit of the values of  $r$  for which these conditions are fulfilled. If the length  $n\rho$  is taken on the vector, and if the vector makes a complete revolution, the value of  $\rho$  for each position being taken, the star  $A_n$  will be generated. Evidently the star  $A_1$  is the true circle of convergence of the series (5), and every star  $A_n$  includes the star  $A_{n-1}$ . From the series of series a series of polynomials depending upon the  $a_i$  and  $n$  may be constructed in an infinity of ways which will represent the function uniformly in  $A_n$  with an error less than an arbitrary  $\epsilon$  given in advance.<sup>6</sup>

<sup>3</sup> *Bulletin des sciences mathématiques*, 1888, p. 148.

<sup>5</sup> *Ibid.*, Vol. XXIII, p. 47.

<sup>4</sup> *Acta Mathematica*, Vol. XXIII, p. 43, and Vol. XXIV, pp. 183, 205.

<sup>6</sup> *Ibid.*, p. 62.

The difficulty in applying this theorem is that there is no way of determining whether a given point belongs to any star  $A_n$  or not. When the series (5) is defined by differential equations, this part of the question becomes considerably simplified. Suppose (5) has been defined by the differential equations which the motion of the moon must fulfil. Then it will be known to converge if  $t = T$ , the value of  $t$ , depending on the initial values of the co-ordinates. Suppose that during the whole interval of time  $0 \leq t \leq T$  the moon is contained within an anchor ring with the earth as center. For every point in this anchor ring as an initial point there is a corresponding  $t_0$ . Let the least value of these numbers  $t$  be  $\rho$ . Now, if the initial conditions are known, it is possible to construct a Mittag-Leffler series of polynomials having a number of terms which can be determined in advance, which will give the value of  $x$  with an error less than an arbitrary  $\epsilon$  for the whole interval of time  $0 \leq t \leq T$ .

In order to apply Mittag-Leffler's process the point  $t = T$  must belong to the star  $A_n$ , where the number  $n$  is to be determined. From the definition of the star it is seen that it suffices to take  $n$  so that  $n\rho \geq T$ . Then the series of polynomials may be set up, the polynomials depending on both  $n$  and the required accuracy  $\epsilon$ . With this series of polynomials an ephemeris may be computed, and if the moon does not pass out of the anchor ring which was used in defining  $\rho$ , and through it  $n$ , the final results will be in error less than  $\epsilon$ . If the moon should pass out of the anchor ring as given by the ephemeris, the results will be in error less than  $\epsilon$  up to the time it crosses the ring. At this point a new ring could be taken. In this manner it is possible to construct a theoretically perfect lunar theory.<sup>7</sup>

#### §4. THE METHOD OF THE VARIATION OF PARAMETERS

The method of variation of parameters, which was partially developed by Euler in his memoirs on the lunar theory, and which was finished by Lagrange in his work on the mutual perturbations of the planets, has been one of very great usefulness in astronomy. Owing to the immense details connected with its applications and to the fact that because of the small masses of the planets only one step of any possible number of steps is required, much confusion has arisen regarding the mathematical features of the process. For example, it is frequently supposed that each step is only a process of approximation.

Consider equations (1) and suppose their right members are series of any sort, except that, if they are infinite, they converge at least in the vicinity of the initial values of the  $x_i$  and  $t$ . Then (1) may be written

$$\frac{dx_i}{dt} = X_i^{(1)} + X_i^{(2)} + X_i^{(3)} + \dots \quad (i=1, \dots, n), \quad (6)$$

Now consider the differential equations

$$\frac{dx_i}{dt} = X_i^{(1)} \quad (i=1, \dots, n), \quad (7)$$

where the  $X_i^{(1)}$  are any terms of the right members of (6). In practice the  $X_i^{(1)}$  are generally the largest terms, but this is not in the least essential to the method. Suppose the solutions of (7) can be exactly found, at least for sufficiently small values of  $t$ , and that they are

$$x_i = f_i^{(1)}(y_1, \dots, y_n, t) \quad (i=1, \dots, n), \quad (8)$$

where  $y_1, \dots, y_n$  are the constants of integration. Suppose these equations are valid if  $0 \leq t \leq T$ , where  $T$  may be infinite.

Since equations (8) are the solutions of (7) if they are substituted in (7), these expressions reduce to identities in  $y_1, \dots, y_n$  and  $t$  for all values of  $t$  less than  $T$ .

<sup>7</sup> Concerned the question, *Proposed a complete century*, June 19, 1899. See also note by PEIRCE, *ibid.*, June 5, 1899.

Now regard equations (8) as equations of transformation expressing the  $n$  old variables  $x_i$  in terms of  $n$  new variables  $y_i$ . The transformation is made by substituting (8) directly in (6), whence

$$\frac{\partial f_i^{(1)}}{\partial t} + \sum_{j=1}^n \frac{\partial f_i^{(1)}}{\partial y_j} \frac{dy_j}{dt} = X_i^{(1)}(y_1, \dots, y_n, t) + X_i^{(2)}(y_1, \dots, y_n, t) + \dots \quad (i=1, \dots, n) \quad (9)$$

Since equations (8) are the solutions of (7), it follows from the definition of solutions that

$$\frac{\partial f_i^{(1)}}{\partial t} = X_i^{(1)}(y_1, \dots, y_n, t) \quad i=1, \dots, n \quad \text{in } y_1, \dots, y_n \text{ and } t,$$

and equations (9) become

$$\sum_{j=1}^n \frac{\partial f_i^{(1)}}{\partial y_j} \frac{dy_j}{dt} = X_i^{(2)}(y_1, \dots, y_n, t) + \dots \quad (i=1, \dots, n) \quad (10)$$

This vanishing of the first terms in the right members, which in practice are much larger than the succeeding ones, constitutes the essential mathematical difference between the method of the variation of parameters and an ordinary transformation of variables.

Equations (10) are linear in the derivatives  $\frac{dy_j}{dt}$  and may be solved for them, giving

$$\frac{dy_i}{dt} = Y_i^{(1)} + Y_i^{(2)} + \dots \quad (i=1, \dots, n) \quad (11)$$

where the right members are written as series constructed according to any desired plan. Equations (11) are valid for all values of  $t$  less than  $T$  if the determinant of the left members of (10), which is the Jacobian of (8), does not vanish in this interval. The Jacobian does not vanish identically, for equations (8) are independent, being the solutions of equations (7), which are by hypothesis independent. It may become zero, however, for special values of  $y_1, \dots, y_n$  and  $t$ . But if equations (6) are in the canonical form, as they can always be written, in considering the motions of the planets as well as in much more general problems, and if the canonical constants are used, the determinant is unity and never vanishes.

In considering the perturbations of the planets the canonical elements are not generally used. When they are not, the determinant will vanish if the  $x_i$  take such values that the solutions of equations (8) for the  $y_i$  give ambiguous or infinite results. When the ordinary elements  $a, e, i, \Omega, \tilde{\omega}$ , and  $\epsilon$  are used,  $\tilde{\omega}$  becomes indeterminate for  $e=0$ ,  $\Omega$  for  $i=0$ , and  $a$  becomes infinite for  $e=1$ ; for these values of  $e$  and  $i$  the determinant of (10) vanishes. This is one of the reasons why Lagrange transformed from  $e$  and  $\tilde{\omega}$  to  $h$  and  $l$ , and from  $i$  and  $\Omega$  to  $p$  and  $q$  in treating the secular terms.

After equations (11) have been found, the problem of integrating them arises, and is in general no less difficult than was the integration of (6). Equations (11) have the same form as (6) and may be treated in the same way, giving, after completing the reductions,

$$\frac{dz_i}{dt} = Z_i^{(1)} + Z_i^{(2)} + \dots \quad (i=1, \dots, n) \quad (12)$$

This process may be continued indefinitely if the first terms in the right members are selected so that when the others are neglected the rigorous integration can be performed. Under these conditions it is perfectly valid for any finite number of repetitions, the question whether it converges when repeated indefinitely remaining unanswered. To treat this question it would be necessary to define in some way the law of procedure.

The method of variation of parameters finds its complete exemplification only in Delaunay's lunar theory where it is consistently followed out. In the theories of the perturbations of the planets it is the first step, after which the method is changed.

## §5. POWER SERIES IN PARAMETERS

The power series in the time given in §2 are not convenient in most problems because of their small realm of convergence. Nevertheless, it is possible to construct from them, as shown in §3, series of polynomials which have a wider realm of convergence. If, instead of using polynomials, more general functions are employed, the practical usefulness of the series can be greatly increased. The most satisfactory method which has been so far devised is to expand the solutions as power series in the parameters which occur in the differential equations.<sup>8</sup> If no natural parameters occur, it is sometimes possible to introduce them artificially so as to attain much the same results.

Suppose the differential equations to be integrated are

$$\frac{dx_i}{dt} = X_i(x_1, \dots, x_n, \alpha, \beta, t) \quad (i=1, \dots, n), \quad (13)$$

where  $\alpha$  and  $\beta$  are parameters. Suppose the initial values of  $x_1, \dots, x_n$  are  $a_1, \dots, a_n$  respectively. Suppose the  $X_i$  are all expandible in converging power series in  $\alpha$  in the vicinity of  $x_j = a_j$  for all values of  $t$  such that  $0 \leq t \leq t_0$ . Suppose the coefficients of the various powers of  $\alpha$  are all expandible as converging power series in  $x_1, \dots, x_n$  in the vicinity of  $x_j = a_j$  for all  $0 \leq t \leq t_0$ .

It is proposed to find solutions having the form

$$x_i = \sum_{j=0}^{\infty} x_i^{(j)} \alpha^j \quad (i=1, \dots, n), \quad (14)$$

where the  $x_i^{(j)}$  are functions of the time to be determined. In determining the  $x_i^{(j)}$  there are two cases, depending on whether the  $X_i$  all vanish with  $\alpha = 0$  or not.

1. *Case in which the  $X_i$  have a factor  $\alpha$ .*—In order to keep this fact prominent, let (13) be written in the form

$$\frac{dx_i}{dt} = \alpha X_i(x_1, \dots, x_n, \alpha, \beta, t). \quad (13')$$

Substituting (14) in (13'), it is found that

$$\begin{aligned} \sum_{j=0}^{\infty} \frac{dx_i^{(j)}}{dt} \alpha^j = \alpha \left\{ X_i(a_1, \dots, a_n) + \frac{\partial X_i}{\partial \alpha} \alpha + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(1)} \alpha^2 + \frac{1}{2} \frac{\partial^2 X_i}{\partial \alpha^2} \alpha^3 + \sum_{j=1}^n \frac{\partial^2 X_i}{\partial \alpha \partial x_j} x_j^{(1)} \alpha^3 + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \frac{\partial^2 X_i}{\partial x_j \partial x_k} x_j^{(1)} x_k^{(1)} \alpha^4 \right. \\ \left. + \sum_{j=1}^n \frac{\partial^3 X_i}{\partial \alpha^2 \partial x_j} x_j^{(1)} \alpha^5 + \dots \right\}, \quad (15) \end{aligned}$$

where in all the partial derivatives  $x_i$  is replaced by  $x_i^{(0)}$  and  $\alpha$  is put equal to zero. Admitting for the moment the convergency of (15), the coefficients of the corresponding powers of  $\alpha$  in the right and left members are equal, giving

$$\begin{aligned} \frac{dx_i^{(0)}}{dt} &= 0 \quad (i=1, \dots, n), \\ \frac{dx_i^{(1)}}{dt} &= X_i(x_1, \dots, x_n, 0, \beta, t), \\ \frac{dx_i^{(2)}}{dt} &= \frac{\partial X_i}{\partial \alpha} + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(1)}, \\ &\text{etc.} \end{aligned} \quad (16)$$

These equations can be integrated in order, being in each case quadratures, and give the coefficients of (14) uniquely.

<sup>8</sup> This method was first used in a somewhat loose way by Laplace when he examined the problem of constructing the theories of the mutual perturbations of the planets. The indefinite "order of small

quantities" was used and has been largely retained up to the present time, rather than an explicit development. CAULY in 1812 examined the validity of the method (*Collected Works*, 1st series, Vol. VII).

2. *Case in which the  $X_i$  do not have the factor  $a$ .*—Substituting (14) in (13), it is found that

$$\sum_{i=0}^{\infty} \frac{dx_i^{(p)}}{dt} a^i = X_i(x_1^{(m)}, \dots, x_n^{(m)}, 0, \beta, t) + \frac{\partial X_i}{\partial a} a + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(1)} a + \frac{1}{2} \frac{\partial^2 X_i}{\partial a^2} a^2 + \sum_{j=1}^n \frac{\partial^2 X_i}{\partial a \partial x_j} x_j^{(1)} a^2 + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \frac{\partial^2 X_i}{\partial x_j \partial x_k} x_j^{(1)} x_k^{(1)} a^2 + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(2)} a^2 + \dots \quad (17)$$

Equating coefficients of corresponding powers of  $a$ , it is found that

$$\begin{aligned} \frac{dx_i^{(0)}}{dt} &= X_i(x_1^{(m)}, \dots, x_n^{(m)}, 0, \beta, t) \quad (i=1, \dots, n), \\ \frac{dx_j^{(1)}}{dt} &= \frac{\partial X_i}{\partial a} + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(1)}, \\ \frac{dx_i^{(2)}}{dt} &= \frac{1}{2} \frac{\partial^2 X_i}{\partial a^2} + \sum_{j=1}^n \frac{\partial^2 X_i}{\partial a \partial x_j} x_j^{(1)} + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \frac{\partial^2 X_i}{\partial x_j \partial x_k} x_j^{(1)} x_k^{(1)} + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(2)}; \end{aligned} \quad (18)$$

and in general

$$\frac{dx_i^{(p)}}{dt} = X_i^{(p)} + \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} x_j^{(p)}, \quad (19)$$

where  $X_i^{(p)}$  is a polynomial in  $x_j^{(0)}, \dots, x_j^{(p-1)}$ . After the  $x_i^{(0)}$  have been determined, the remaining  $x_i^{(p)}$  depend upon the solution of systems of linear non-homogeneous differential equations.

This case may always be avoided by eliminating the parts of the  $X_i$  which are independent of  $a$  by the method of the variation of parameters, but it is not always advisable to do so.

3. *Determination of constants of integration.*—Every time a set of equations of (16) is integrated  $n$  constants are introduced, and they must be determined in terms of the initial values of the variables. Let the constants introduced with  $x_i^{(p)}$  be  $a_i^{(p)}$ ; then, letting  $x_i^{(p)}$  be written  $f_i^{(p)}(t) - a_i^{(p)}$ , equations (14) become

$$x_i = a_i^{(m)} + \sum_{j=1}^{\infty} [f_i^{(j)}(t) - a_i^{(j)}] a^j \quad (i=1, \dots, n).$$

At the initial time  $t=0$  these equations become

$$a_i = a_i^{(m)} + \sum_{j=1}^{\infty} [f_i^{(j)}(0) - a_i^{(j)}] a^j \quad (i=1, \dots, n). \quad (20)$$

If these equations have any realm of convergency in  $a$  for  $0 \equiv t < t_0$ , they become identities in  $a$ , because the initial values of the variables are independent of the parameters, and it follows that

$$\begin{aligned} a_i^{(0)} &= a_i & (i=1, \dots, n), \\ a_i^{(j)} &= f_i^{(j)}(0) & (i=1, \dots, j=1, \dots, \infty). \end{aligned} \quad (21)$$

It follows from these relations that, when the  $X_i$  vanish with  $a$ , the  $x_i^{(p)}$  are the definite integrals of the equations by which they are defined taken between the limits  $t=0$  and  $t=t$ .

When the  $X_i$  do not vanish with  $a$ , the constants are not additive. The way they enter in the expressions for  $x_i^{(p)}$  depends upon the forms of the right members of the first set of equations (18). In the solutions of the linear equations which occur after the first set they enter in the form

$$x_i^{(p)} = \sum_{j=1}^n c_{ij}^{(p)} f_j^{(p)}(t) + \phi_i^{(p)}(t) \quad (i=1, \dots, n \quad p=1, \dots, \infty), \quad (22)$$

where the  $c_i^{\nu}$  are related to the  $c_i^{\nu} = 2, \dots, n$  by the coefficients which are involved in the differential equations. At  $t = 0$  the solutions (14) become

$$a_i = x_i^{(0)} + \sum_{\nu=1}^{\infty} \left\{ \sum_{j=1}^n c_{ij}^{\nu} f_j^{(\nu)}(0) + \phi_i^{(\nu)}(0) \right\} a^{\nu} \quad (i=1, \dots, n). \quad (23)$$

If these equations have any realm of convergency, they are identities in  $a$ . Hence  $(x_i^{(0)})_{t=0} = a_i$ , and the independent constants  $c_{ij}^{(0)}$  which enter linearly are determined by the equations

$$\sum_{j=1}^n c_{ij}^{\nu} f_j^{(\nu)}(0) + \phi_i^{(\nu)}(0) = 0 \quad (i=1, \dots, n), \quad (24)$$

and a similar system for all values of  $\nu$  from 1 to  $\infty$ . It follows from this that the  $x_i^{(0)}$  are the definite integrals

$$x_i^{(0)} = \int_0^{t_0} \frac{dx_i^{(0)}}{dt} dt \quad (i=1, \dots, n; \nu=1, \dots, \infty),$$

The question of the convergency of these series was first examined by Cauchy in a series of papers published in *Comptes rendus* in the summer of 1842.<sup>10</sup> The method is to use a comparison set of differential equations,

$$\frac{dy_i}{dt} = Y_i(y_1, \dots, y_n, a, \beta, t) \quad (i=1, \dots, n), \quad (25)$$

where the  $Y_i$  fulfil all the conditions imposed upon the  $X_i$ , and the additional ones, that the coefficients of the expansions of the coefficients of the various powers of  $a$  shall be real, positive, and greater than the moduli of the corresponding coefficients in the expansions of the  $X_i$  for all  $0 \leq t < t_0$ . Then it is shown that, if the solutions of (25) are written in the form

$$y_i = \sum_{j=0}^{\infty} y_i^{(j)} a^j, \quad (26)$$

the  $y_i^{(j)}$  are all real, positive, and greater than the moduli of the corresponding coefficients of the series (14) for all  $0 \leq t < t_0$ . Consequently series (14) converge if (26) converge.

There are always equations fulfilling the conditions imposed upon (25) of the form

$$\begin{aligned} \frac{dy_i}{dt} &= \frac{aC}{(1-\rho a)[1-r(y_1+\dots+y_n)]}, \text{ or} \\ \frac{dy_i}{dt} &= \frac{C}{(1-\rho a)[1-r(y_1+\dots+y_n)]}, \end{aligned} \quad (27)$$

according as the right members vanish with  $a$  or not, and where  $C$ ,  $\rho$ , and  $r$  are constants conveniently chosen. Equations (27) can be integrated and the  $y_i$  expressed as series in  $a$  which, from the form of the functions which are expanded, are known to converge if  $t$  and  $a$  are sufficiently small. Hence it follows that the series (14) converges if  $t$  and  $a$  are sufficiently small. The limits within which the series are certainly convergent determined in this way are undoubtedly in general much too small.

Poincaré has proved that for any finite value  $t_0$  the  $a$  may be chosen so small that the series converges for all  $0 \leq t < t_0$ , provided that the solutions of (14) with  $a = 0$  have no singularities for this range of time. It follows equally that for any values of  $a$  for which the right members of (13) converge the  $t_0$  may be taken so small that (14) converges for all  $0 \leq t < t_0$ ; and, therefore, any solutions of a problem which are constructed in this manner have at least a positive finite realm of validity in  $t$ .

The parameter  $\beta$  enters in the differential equations (13), and so far it has not been defined,

<sup>10</sup> *Annales de Mathématiques*, Vol. VII.

<sup>11</sup> *Leçons sur les courbes algébriques*, Vol. I, pp. 58-61.

except that it has been tacitly assumed that it does not take values which would introduce singularities in their right members. In particular, there is in general no reason why it may not be numerically equal to  $a$ , although the expansions are made with respect to  $a$  alone. The following is the use which will be made of the  $\beta$ : Suppose that in the differential equations a certain parameter  $\mu$  occurs in two distinct ways; one, such that the right members may be expanded as power series in it in a simple manner; the other, such that the expansions are more difficult, or even impossible. When  $\mu$  occurs in the first way it may be replaced by  $a$ , and when it appears in the second way by  $\beta$ . The solutions may be expanded as power series in  $a$ , and at the end  $a$  and  $\beta$  given their numerical values, which are equal. This artifice, which appears not to have been heretofore employed, is essential in the proof of the validity of many of the processes which have been employed in celestial mechanics with success without it having been demonstrated that they were valid; and, in constructing new series for solutions of differential equations, it opens up such a number of possibilities within the realm of validity that the chances of securing proved rigor and at the same time practicability are greatly increased. These remarks are illustrated in the applications which follow.

Instead of there being one parameter  $a$ , there may be any number, when the solutions will be multiple series. Corresponding theorems respecting the convergence hold.

#### §6. APPLICATION TO THE COMPUTATION OF THE ABSOLUTE PERTURBATIONS OF THE ELEMENTS

Suppose there are the sun, whose mass will be taken as unity, and two planets whose masses are  $m_1$  and  $m_2$ . If the origin is taken at the center of the sun, the differential equations of motion in rectangular co-ordinates are:

$$\begin{aligned} \frac{dx_1}{dt} - x_1' &= 0, & \frac{dx_1'}{dt} + k^2(1+m_1)\frac{x_1}{r_1^3} &= m_2 \frac{\partial R_1}{\partial x_1}, \\ \frac{dy_1}{dt} - y_1' &= 0, & \frac{dy_1'}{dt} + k^2(1+m_1)\frac{y_1}{r_1^3} &= m_2 \frac{\partial R_1}{\partial y_1}, \\ \frac{dz_1}{dt} - z_1' &= 0, & \frac{dz_1'}{dt} + k^2(1+m_1)\frac{z_1}{r_1^3} &= m_2 \frac{\partial R_1}{\partial z_1}, \\ \frac{dx_2}{dt} - x_2' &= 0, & \frac{dx_2'}{dt} + k^2(1+m_2)\frac{x_2}{r_2^3} &= m_1 \frac{\partial R_2}{\partial x_2}, \\ \frac{dy_2}{dt} - y_2' &= 0, & \frac{dy_2'}{dt} + k^2(1+m_2)\frac{y_2}{r_2^3} &= m_1 \frac{\partial R_2}{\partial y_2}, \\ \frac{dz_2}{dt} - z_2' &= 0, & \frac{dz_2'}{dt} + k^2(1+m_2)\frac{z_2}{r_2^3} &= m_1 \frac{\partial R_2}{\partial z_2}; \end{aligned} \quad (28)$$

$$\begin{aligned} R_1 &= k^2 \left[ \frac{1}{r_{1,2}} - \frac{x_1 x_2 + y_1 y_2 + z_1 z_2}{r_1^3} \right], \\ R_2 &= k^2 \left[ \frac{1}{r_{1,2}} - \frac{x_2 x_1 + y_2 y_1 + z_2 z_1}{r_1^3} \right], \end{aligned}$$

where  $r_1$  and  $r_2$  are the distances from  $m_1$  and  $m_2$  to the sun and  $r_{1,2}$  is the distance between  $m_1$  and  $m_2$ .

When the right members are put equal to zero, the equations reduce to those for the problem of two bodies, and can be solved. Consequently the method of the variation of parameters can be employed as explained in §4. Suppose the elements of the orbit of  $m_1$  are  $a_1, a_2, \dots, a_6$ , and of  $m_2, b_1, b_2, \dots, b_6$ . Then, after the method of the variation of parameters has been applied once, the differential equations will have the form

$$\begin{aligned} \frac{da_i}{dt} &= m_2 \phi_i(a_1, \dots, a_6, b_1, \dots, b_6, t) & (i=1, \dots, 6), \\ \frac{db_i}{dt} &= m_1 \psi_i(a_1, \dots, a_6, b_1, \dots, b_6, t). \end{aligned} \quad (29)$$

The distribution of the parameters into  $\alpha$ 's and  $\beta$ 's must be made before equations (29) are integrated. The parameters are  $m_1$  and  $m_2$ , which appear in the right members as factors. The functions  $\phi_i$  and  $\psi_i$  originally depended upon the co-ordinates  $x_1, y_1, z_1, x_2, y_2, z_2$ . These were eliminated by means of the solutions of (28) after the right members were put equal to zero; but, since the left members of (28) involve  $m_1$  and  $m_2$ , the functions  $\phi_i$  and  $\psi_i$  involve  $m_1$  and  $m_2$  implicitly. In order to simplify matters and to establish the validity of the ordinary expressions which are used in the theory of absolute perturbations, the  $m_1$  and  $m_2$  which occur as factors of  $\phi_i$  and  $\psi_i$  respectively will be regarded as being  $\alpha$ 's and those which enter implicitly in  $\phi_i$  and  $\psi_i$  as being  $\beta$ 's. If this were not done, the  $\phi_i$  and  $\psi_i$  would have to be expanded as power series in  $m_1$  and  $m_2$ ,<sup>11</sup> thus adding enormously to the labor of practically carrying out the work, while the expressions obtained would not be those used by astronomers.

The problem now is to integrate equations (29), which are as general as (28) and valid so long as the Jacobian of the equations of transformation does not vanish. In the mutual perturbations of the planets it never vanishes when the elements are conveniently defined. It is no more possible to obtain integrals of (29) in finite numbers of terms than it was in the case of (28), but it is possible to integrate them as power series in  $m_1$  and  $m_2$ , which will, as was seen in § 5, absolutely converge so long as  $t$  is not too far from its initial value.

It will now be shown how the coefficients of the series can be computed, and that the various terms have obvious physical interpretations. The solutions are to have the forms<sup>12</sup>

$$\begin{aligned} a_i &= \sum_{j,k=0}^{\infty} a_i^{(j,k)} m_1^j m_2^k & (i=1, \dots, 6) , \\ b_i &= \sum_{j,k=0}^{\infty} b_i^{(j,k)} m_1^j m_2^k \end{aligned} \quad (30)$$

where the  $a_i^{(j,k)}$  and the  $b_i^{(j,k)}$  are functions of the time to be determined. It will be supposed that the terms are arranged so that the sum  $j+k$  proceeds in the order of the natural numbers.

Substituting (30) in (29), it is found that

$$\begin{aligned} \frac{da_i^{(j,k)}}{dt} &= \frac{da_i^{(j,k)}}{dt} m_2 + \frac{da_i^{(j,k)}}{dt} m_1 + \frac{da_i^{(j,k)}}{dt} m_1 m_2 + \frac{da_i^{(j,k)}}{dt} m_2^2 + \frac{da_i^{(j,k)}}{dt} m_1^2 + \dots \\ &= m_2 \phi_i(a_1^{(0,0)}, \dots, a_6^{(0,0)}, b_1^{(0,0)}, \dots, b_6^{(0,0)}, t) + m_2 \sum_{j=1}^6 \frac{\partial \phi_i}{\partial a_j} (a_j^{(0,1)} m_2 + a_j^{(1,0)} m_1) \\ &\quad + m_2 \sum_{j=1}^6 \frac{\partial \phi_i}{\partial b_j} (b_j^{(0,1)} m_2 + b_j^{(1,0)} m_1) + \text{higher powers in } m_1 \text{ and } m_2 , \\ \frac{db_i^{(j,k)}}{dt} &= \frac{db_i^{(j,k)}}{dt} m_2 + \frac{db_i^{(j,k)}}{dt} m_1 + \frac{db_i^{(j,k)}}{dt} m_1 m_2 + \frac{db_i^{(j,k)}}{dt} m_2^2 + \frac{db_i^{(j,k)}}{dt} m_1^2 + \dots \\ &= m_1 \psi_i(a_1^{(0,0)}, \dots, a_6^{(0,0)}, b_1^{(0,0)}, \dots, b_6^{(0,0)}, t) + m_1 \sum_{j=1}^6 \frac{\partial \psi_i}{\partial a_j} (a_j^{(0,1)} m_2 + a_j^{(1,0)} m_1) \\ &\quad + m_1 \sum_{j=1}^6 \frac{\partial \psi_i}{\partial b_j} (b_j^{(0,1)} m_2 + b_j^{(1,0)} m_1) + \text{higher powers in } m_1 \text{ and } m_2 . \end{aligned} \quad (31)$$

Equating coefficients of corresponding powers of  $m_1$  and  $m_2$  in the right and left members of these equations, it is found that

<sup>11</sup> Compare POINCARÉ, *Mécanique céleste*, Vol. I, p. 270 where this expression is given.

<sup>12</sup> Compare the "order of small quantity" method given by Tisserand, *Mécanique céleste*, Vol. I, p. 191.

$$\begin{aligned}\frac{da_i^{(n,0)}}{dt} &= 0, & (i=1, \dots, 6), \\ \frac{db_i^{(0,n)}}{dt} &= 0,\end{aligned}\tag{32}$$

$$\begin{aligned}\frac{da_i^{(n,1)}}{dt} &= \phi_i(a_1^{(0,0)}, \dots, a_6^{(0,0)}, b_1^{(0,0)}, \dots, b_6^{(0,0)}, t) & (i=1, \dots, 6), \\ \frac{da_i^{(1,0)}}{dt} &= 0, \\ \frac{db_i^{(0,1)}}{dt} &= 0, \\ \frac{db_i^{(1,0)}}{dt} &= \psi_i(a_1^{(0,0)}, \dots, a_6^{(0,0)}, b_1^{(0,0)}, \dots, b_6^{(0,0)}, t),\end{aligned}\tag{33}$$

$$\begin{aligned}\frac{da_i^{(1,1)}}{dt} &= \sum_{j=1}^6 \frac{\partial \phi_i}{\partial a_j} a_j^{(1,0)} + \sum_{j=1}^6 \frac{\partial \phi_i}{\partial b_j} b_j^{(1,0)} & (i=1, \dots, 6), \\ \frac{da_i^{(0,2)}}{dt} &= \sum_{j=1}^6 \frac{\partial \phi_i}{\partial a_j} a_j^{(0,1)} + \sum_{j=1}^6 \frac{\partial \phi_i}{\partial b_j} b_j^{(0,1)}, \\ \frac{da_i^{(2,0)}}{dt} &= 0, \\ \frac{db_i^{(1,1)}}{dt} &= \sum_{j=1}^6 \frac{\partial \psi_i}{\partial a_j} a_j^{(0,1)} + \sum_{j=1}^6 \frac{\partial \psi_i}{\partial b_j} b_j^{(0,1)}, \\ \frac{db_i^{(2,0)}}{dt} &= \sum_{j=1}^6 \frac{\partial \psi_i}{\partial a_j} a_j^{(1,0)} + \sum_{j=1}^6 \frac{\partial \psi_i}{\partial b_j} b_j^{(1,0)}, \\ \frac{db_i^{(0,2)}}{dt} &= 0, \\ &\text{etc.}\end{aligned}\tag{34}$$

Integrating (32) and substituting the values of  $a_i^{(n,0)}$  and  $b_i^{(0,n)}$  thus obtained in (33), the latter are reduced to quadratures and can be integrated; integrating (33) and substituting the expressions for  $a_i^{(0,1)}$ ,  $a_i^{(1,0)}$ ,  $b_i^{(0,1)}$ , and  $b_i^{(1,0)}$  in (34), the latter are reduced to quadratures and can be integrated; and this process may be repeated indefinitely, giving any desired number of coefficients of the series (30). When valid processes in performing the quadratures are employed, the elements are rigorously determined within certain time limits.<sup>13</sup>

An additive constant of integration is introduced with each integration which can be determined, as was shown in § 5, from the initial conditions. Suppose  $a_i^{(j,k)} = f_i^{(j,k)}(t) - \alpha_i^{(j,k)}$ ,  $b_i^{(j,k)} = g_i^{(j,k)}(t) - \beta_i^{(j,k)}$ , where the  $\alpha_i^{(j,k)}$  and  $\beta_i^{(j,k)}$  are the constants of integration to be determined. Let the initial values of  $a_i$  and  $b_i$  be  $a_i^{(0)}$  and  $b_i^{(0)}$  respectively. Then equations (30) become at  $t = 0$

$$\begin{aligned}a_i^{(0)} &= \sum_{j,k=0}^{\infty} [f_i^{(j,k)}(0) - \alpha_i^{(j,k)}] m_1^j m_2^k & (i=1, \dots, 6), \\ b_i^{(0)} &= \sum_{j,k=0}^{\infty} [g_i^{(j,k)}(0) - \beta_i^{(j,k)}] m_1^j m_2^k.\end{aligned}\tag{35}$$

<sup>13</sup> Compare the statement in DZIOBEK, *Planeten-Bewegungen*, p. 167.

Since the osculating elements are independent of the disturbing masses, these series are identities in  $m_1$  and  $m_2$ , whence

$$\begin{aligned} a_i^{(0)} &= a_i^*, \\ b_i^{(0,0)} &= b_i^{(0)}, \\ a_i^{(j,k)} &= 0 & (j=1, \dots, \infty), \\ b_i^{(0,k)} &= 0 & (k=1, \dots, \infty), \\ f_i^{(j,k)}(0) - a_i^{(j,k)} &= 0 & (j=1, \dots, \infty, k=1, \dots, \infty), \\ g_i^{(j,k)}(0) - \beta_i^{(j,k)} &= 0 & (j=1, \dots, \infty, k=1, \dots, \infty). \end{aligned} \quad (36)$$

The  $a_i^{(0)}$  and  $b_i^{(0)}$  are the osculating elements at the time  $t = 0$ , and the perturbations of the first order with respect to the masses are given by (33), which, because of (36), reduce to

$$\begin{aligned} \frac{da_i^{(0,1)}}{dt} &= \phi_i(a_i^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t), \\ \frac{db_i^{(1,0)}}{dt} &= \psi_i(a_i^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t). \end{aligned} \quad (37)$$

The right members of these equations are proportional to the rates at which the various elements of the orbits of the two planets would vary at the time  $t$  if the planets were moving at that instant in the original ellipses; the integrals are the summations of the changes which would be produced if the forces and their instantaneous effects were always exactly equal to those in the undisturbed orbits. Of course, the perturbations modify the expressions for the true rates at which the elements vary, but they are taken care of in terms of higher order.

Since the differential equations (29) involve the parameters  $m_1$  and  $m_2$  to the first degree only, they are valid for all finite values. Consequently this method of computing the absolute perturbations does not depend for its validity upon the fact that the masses of the planets are small compared to that of the sun. However, the smaller the masses of the planets are, the longer the time for which the series converge.

If there were a third planet, the elements  $a_i$  and  $b_i$  would have terms of the first order of the general type of the right members of (37) coming from its attraction, but the effects of each planet in the terms of the first order would be computed separately.

As a consequence of (36) and (37) the terms of the second order, given by (34), reduce to

$$\begin{aligned} \frac{da_i^{(1,1)}}{dt} &= \sum_{j=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial b_j^{(0)}} b_j^{(1,0)} & (i=1, \dots, 6), \\ \frac{da_i^{(0,2)}}{dt} &= \sum_{j=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial a_j^{(0)}} a_j^{(0,1)}, \\ \frac{db_i^{(1,1)}}{dt} &= \sum_{j=1}^6 \frac{\partial \psi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial a_j^{(0)}} a_j^{(0,1)}, \\ \frac{db_i^{(1,2)}}{dt} &= \sum_{j=1}^6 \frac{\partial \psi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial b_j^{(0)}} b_j^{(0,1)}. \end{aligned} \quad (38)$$

The perturbations of the second order arise from the fact that both  $m_1$  and  $m_2$  depart from their original ellipses by terms of the first order. The perturbations of the second order of the elements of  $m_1$ , due to the fact that  $m_2$  departs from its original orbit by terms of the first order, are given by equations of the type of the first of (38); for, if  $b_j^{(1,0)}$ , the first-order perturbations of  $m_2$ , were zero,  $a_i^{(1,1)}$  would be zero also. Similarly, the perturbations of the second order of  $m_1$ , due to the fact that  $m_2$  departs from its original ellipse by terms of the first order, are given by equations of the

type of the second of (38). The terms  $b_i^{(1,1)}$  and  $b_i^{(2,0)}$  in the elements of the orbit of  $m_2$  arise from similar causes. Thus the terms of the second order correct the errors which would be committed by stopping with terms of the first order, and those of the third order correct those of the second, and so on indefinitely.

If there are three planets, the perturbations of the second order are considerably more complicated, the terms arising from the attractions of the various planets not appearing separately, as they do in case of the terms of the first order. Suppose the third planet is  $m_3$  and that the elements of its orbit are  $c_1, \dots, c_6$ . Then the differential equations which define the terms of the second order are

$$\begin{aligned}
 \frac{da_j^{(1,1,0)}}{dt} &= \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial b_j^{(0)}} b_j^{(1,0,0)} & (i=1, \dots, 6), \\
 \frac{da_j^{(1,0,1)}}{dt} &= \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, c_1^{(0)}, \dots, c_6^{(0)}, t)}{\partial c_j^{(0)}} c_j^{(1,0,0)}, \\
 \frac{da_j^{(0,2,0)}}{dt} &= \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial a_j^{(0)}} a_j^{(0,1,0)}, \\
 \frac{da_j^{(0,0,2)}}{dt} &= \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, c_1^{(0)}, \dots, c_6^{(0)}, t)}{\partial a_j^{(0)}} a_j^{(0,0,1)}, \\
 \frac{da_j^{(0,1,1)}}{dt} &= \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial a_j^{(0)}} a_j^{(0,0,1)} \\
 &\quad + \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, b_1^{(0)}, \dots, b_6^{(0)}, t)}{\partial b_j^{(0)}} b_j^{(0,0,1)}, \\
 &\quad + \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, c_1^{(0)}, \dots, c_6^{(0)}, t)}{\partial a_j^{(0)}} a_j^{(0,1,0)}, \\
 &\quad + \sum_{i=1}^6 \frac{\partial \phi_i(a_1^{(0)}, \dots, a_6^{(0)}, c_1^{(0)}, \dots, c_6^{(0)}, t)}{\partial c_j^{(0)}} c_j^{(0,1,0)},
 \end{aligned} \tag{39}$$

and the corresponding equations for  $\frac{db_i}{dt}$  and  $\frac{dc_i}{dt}$ .

Equations of the type of the first give the perturbations arising from the attraction of  $m_2$  due to the fact that  $m_2$  has been drawn from its original ellipse by  $m_1$ ; the second, the perturbations arising from the attraction of  $m_3$  due to the fact that  $m_3$  has been drawn from its original ellipse by  $m_1$ ; the third, the perturbations arising from the attraction of  $m_2$  due to the fact that  $m_1$  has been drawn from its original ellipse by  $m_2$ ; the fourth, the perturbations arising from the attraction of  $m_3$  due to the fact that  $m_1$  has been drawn from its original ellipse by  $m_3$ ; the first term of the fifth, the perturbations arising from the attraction of  $m_2$  due to the fact that  $m_1$  has been drawn from its original ellipse by  $m_3$ ; the second term of the fifth, the perturbations arising from the attraction of  $m_2$  due to the fact that  $m_2$  has been drawn from its original ellipse by  $m_3$ ; the third term of the fifth, the perturbations arising from the attraction of  $m_3$  due to the fact that  $m_1$  has been drawn from its original ellipse by  $m_2$ ; and the fourth term of the fifth, the perturbations arising from the attraction of  $m_3$  due to the fact that  $m_3$  has been drawn from its original ellipse by  $m_2$ . Thus precisely those terms appear which would be expected from physical considerations.

Consider the general case in which there are  $n$  planets  $m_1, \dots, m_n$ . The planet  $m_1$ , for example, suffers first-order perturbations due to the attraction of  $m_2$ . This deviation of  $m_1$  from its elliptical orbit gives terms of the second order arising from the attraction of each of the remaining planets,

thus giving  $n-1$  terms of the second order. Similar results arise from the first-order perturbations of  $m_1$  by  $m_2$ , and so on down to the planet  $m_n$ . Since there are  $n-1$  planets besides  $m_1$ , there are in all  $(n-1)^2$  terms of the second order in the perturbations of every element of the orbit of  $m_1$  due to the fact that it has deviated from its original orbit by terms of the first order. The elements of the orbit of  $m_2$  have  $n-1$  terms of the first order arising from the attraction of the remaining  $n-1$  planets for it, and each of these gives rise to a term of the second order in the perturbations of the elements of the orbit of  $m_1$ , or  $n-1$  new terms of the second order. This is true for each of the remaining planets, so that there are in all  $(n-1)^2$  terms of the second order in the perturbations of every element of the orbit of  $m_1$ , due to the fact that  $m_2, \dots, m_n$  depart from their original ellipses by terms of the first order. Therefore each element of the orbit of  $m_1$  has  $2(n-1)^2$  different perturbations of the second order, and for the whole  $n$  planets there are  $2n(n-1)^2$  terms of the second order. When there are two planets, there are four terms of the second order, given by equations (38). When there are three planets, there are twenty-four terms, the first eight of which are given in (39). When there are eight planets, as in the solar system, there are 784 terms of the second order for each of the six elements. Fortunately nearly all of them are so small as to be insensible.<sup>11</sup>

In order that the conclusions may be sound, the quadratures must be made by valid processes. In the case of the mutual perturbations of the great planets it can be shown that the series which are ordinarily employed in preparation for the quadratures are convergent.

#### §7. A VALID METHOD OF AVOIDING SECULAR TERMS OF THE FIRST ORDER

In the right members of the differential equations which define the perturbations of the first order with respect to the masses there are, in the expansions which are usually employed, terms of two types: (*a*) those in which the time is involved in the cosine or sine functions, and (*b*) those which are independent of the time. Upon integration the first type gives sine and cosine terms, which are consequently periodic and always finite; but the second type gives terms which change indefinitely with the time.<sup>12</sup> In the perturbations of the second order with respect to the masses there are, except in the case of the major axes, periodic terms, terms which contain the time and periodic terms as products, which will be called Poisson terms, terms containing the time to the first degree, and terms containing the time to the second degree. In perturbations of the third order with respect to the masses there are terms of the third degree in the time; etc.

Although terms appear which change indefinitely with the time, it does not in the least follow that the elements change indefinitely with the time. It may be that these so-called *secular terms* are the expansions of periodic terms, and, if so, it is desirable, at least for practical purposes, that the expanded forms be avoided. The question arises if this may not be done by modifying the method of integrating the differential equations. Whether it can be done or not, it *proves* nothing regarding the stability of the system, unless the series can be proved to be uniformly convergent; but this problem has not even been approached yet, much less solved.<sup>13</sup> Lagrange has succeeded in showing<sup>14</sup> by formal processes that the secular terms of the first order of the masses and of the first order in the eccentricities and mutual inclinations may be avoided entirely. Leverrier has shown<sup>15</sup> that when terms of the fourth order in the eccentricities and inclinations in the perturbative function are included, the solutions still retain the periodic form. Finally, Poincaré has shown<sup>16</sup> that the secular terms of all orders may formally be integrated in series which are periodic. He says, in

<sup>11</sup> The coefficients of the various powers of the masses are here

<sup>12</sup> The coefficients of the various powers of the masses are here

<sup>13</sup> There is the well-known exception in the case of the major axes.

<sup>14</sup> See *Essai sur la Théorie du Calcul des Probabilités*, p. 40. The generally accepted erroneous view regarding this matter is advanced.

<sup>15</sup> *Collected Works*, Vols. V and VI.

<sup>16</sup> *Annales de l'Observatoire de Paris*, Vol. II, Addition III.

<sup>17</sup> *Les méthodes nouvelles de la Mécanique céleste*, Vol. II, chap. i.

conclusion,<sup>20</sup> that Lagrange and Laplace would have regarded this as completely establishing the stability of the solar system, but that it is not sufficient now because of the lack of proof of convergence of the series.

The question arises how far the method of Lagrange leads to significant results, for the assumptions and approximations may be such that the conclusions may be erroneous, especially when long intervals of time are involved.<sup>21</sup> In a general way this is the subject of the present inquiry, and it will be shown that results which are, from a practical point of view, sensibly the same, though not quite, may be obtained by processes which have been proved to be valid for not too long a time.

Let the elements of the orbit of the planet  $m_j$  be  $a_j$ ,  $e_j$ ,  $\tilde{\omega}_j$ ,  $\epsilon_j$ ,  $\Omega_j$ , and  $i_j$ , where the letters have the usual significations. Then let the variables  $h_j$ ,  $l_j$ ,  $p_j$ , and  $q_j$  be defined by the equations

$$\begin{aligned} h_j &= e_j \sin \tilde{\omega}_j & (j=1, \dots, n) , \\ l_j &= e_j \cos \tilde{\omega}_j , \\ p_j &= \tan i_j \sin \Omega_j , \\ q_j &= \tan i_j \cos \Omega_j . \end{aligned} \quad (40)$$

Then the differential equations become

$$\begin{aligned} \frac{da_j}{dt} &= f_j(a_k, \epsilon_k, h_k, l_k, p_k, q_k, t) & (j=1, \dots, n) , \quad (k=1, \dots, n) , \\ \frac{d\epsilon_j}{dt} &= g_j(a_k, \epsilon_k, h_k, l_k, p_k, q_k, t) , \\ \frac{dh_j}{dt} &= \theta_j(a_k, \epsilon_k, h_k, l_k, p_k, q_k, t) , \\ \frac{dl_j}{dt} &= \phi_j(a_k, \epsilon_k, h_k, l_k, p_k, q_k, t) , \\ \frac{dp_j}{dt} &= \psi_j(a_k, \epsilon_k, h_k, l_k, p_k, q_k, t) , \\ \frac{dq_j}{dt} &= \chi_j(a_k, \epsilon_k, h_k, l_k, p_k, q_k, t) . \end{aligned} \quad (41)$$

The perturbative functions for the various pairs of planets, upon which the right members of equations (41) depend, have the form<sup>22</sup>

$$R_{j,k} = \sum M e_j^H e_k^H \left( \tan \frac{i_j}{2} \right)^G \left( \tan \frac{i_k}{2} \right)^G \cos(a_j + a' l_k + \beta \tilde{\omega}_j + \beta' \tilde{\omega}_k + \gamma \Omega_j + \gamma' \Omega_k) , \quad (42)$$

where  $\bar{l}_j = n_j t - \epsilon_j$ ,  $n_j$  being the mean motion of  $m_j$ . The summation extends over all integral values of  $a, a', \beta, \beta', \gamma, \gamma'$ , and  $H, H', G$ , and  $G'$  are respectively equal to the numerical values of  $\beta, \beta', \gamma, \gamma'$  increased by zero or positive integers, and  $M$  are functions of  $a_j$  and  $a_k$ . Now,  $\tan \frac{i}{2}$  is related to  $\tan i$  by the equation

$$\tan i = \frac{2 \tan \frac{i}{2}}{1 - \tan^2 \frac{i}{2}} ,$$

from which it easily follows that  $\tan \frac{i}{2}$  is expressible as an infinite series of odd powers of  $\tan i$ .

Therefore  $\left( \tan \frac{i_j}{2} \right)^G$  is expressible as an infinite series in  $\tan i$ , with even or odd exponents according

<sup>20</sup> *Loc cit.*, p. 46.

<sup>22</sup> See TISSERAND, *Mécanique céleste*, Vol. I, p. 317.

<sup>21</sup> See DZIOBEK, *Planeten-Bewegungen*, p. 275; TISSERAND *Mécanique céleste*, Vol. I, p. 429.

as  $G$  is even or odd, and (42) may be written

$$R_{j,k} = \sum M^{(p,q)} (\tan i_j)^k (\tan i_k)^k \cos (\alpha l_j + \alpha' l_k + \beta \tilde{\omega}_j + \beta' \tilde{\omega}_k + \gamma \Omega_j + \gamma' \Omega_k), \quad (43)$$

where  $K$  and  $K'$  equal the numerical values of  $\gamma$  and  $\gamma'$  plus zero or positive integers.

It is known that  $\cos vx$  and  $\sin vx$  are expressible as sums of powers of  $\cos x$  and  $\sin x$  respectively, where the highest power is  $v$  and the various powers are all even or odd according as  $v$  is even or odd. Consequently it follows from the relations of the exponents  $H, H', K$ , and  $K'$  to the coefficients  $\beta, \beta', \gamma$ , and  $\gamma'$ , and from the equations  $c_j^2 = h_j^2 + l_j^2$  and  $\tan^2 i_j = p_j^2 + q_j^2$ , that  $R_{j,k}$  is expressible as a power series in  $h_j, h_k, l_j, l_k, p_j, p_k, q_j, q_k$ ; and these series converge for the values of the arguments that occur in the case of the mutual perturbations of the major planets. Therefore the right members of equations (41) are linear in the mass factors  $m_k$  ( $k=1, \dots, j-1, j+1, \dots, n$ ), and, since the coefficients of the partial derivatives of the perturbative function are expansible as series in  $h_j, h_k, \dots, q_j, q_k$ , they are power series in  $h_j, h_k, \dots, q_j, q_k$  with the  $a_k$  entering in the  $M$ 's and the  $\epsilon_k$  entering only under the trigonometric functions.

The secular terms are those in which every  $a, a'$  occurring in the perturbative functions (43) is zero. It should be remarked here that others would occur if the mean motions of any two of the planets were commensurable, but as there are in every case within the limits of accuracy of the observations an infinite number of incommensurable as well as commensurable ratios, it is always assumed that the mean motions are incommensurable. There are no secular terms in the case of the element  $a_j$  for  $a = a' = 0$ , but this element would have secular terms if the mean motions were commensurable.

Lagrange treated the equations (41) by taking out the secular terms in the case of the last four variables, neglecting all except their first powers, and, assuming the  $a_j$  to be constant, he integrated the resulting linear homogeneous system whose coefficients were by assumption constants. He found the solutions and showed that they are all periodic functions of the time. The periodic parts of (41) which remained were integrated by quadratures by considering the elements as constants in the right members. It is perfectly clear that this method, which leads to the only existing theoretical conclusions regarding the stability of the solar system—to the so-called Magna Charta of the permanence of the solar system in its present form—contains a number of assumptions of a very radical type, and that it leads to no such general conclusions as have been drawn from it. Nevertheless, it undoubtedly represents quite approximately the actual changes which the system will undergo for a very long time. The method which is about to be explained gives much the same terms and is proved to be perfectly valid for a positive finite time.

Suppose the secular and periodic parts of the right members of (41) are written separately. Then let the mass factors  $m_k$  which occur as coefficients of the secular terms be replaced by  $\frac{m'_k}{\mu}$ , but remain unchanged in the case of the periodic terms. In the final results  $m'_k$  is to be given the numerical value of  $m_k$  and  $\mu$  is to be put equal to unity. Let  $h_k, l_k, p_k$ , and  $q_k$  everywhere in the secular terms be replaced by  $\mu h_k, \mu l_k, \mu p_k, \mu q_k$ . Then the right members of (41) will be composed of two parts. One part will not involve the time explicitly and will be power series in  $\mu$ , beginning with a term which is independent of this parameter. The other part will involve the time under the cosine and sine functions, and will be linear and homogeneous in the parameters  $m_1, \dots, m_n$ . The first part gives rise to the so-called secular terms and the second part to the periodic and long-period terms. The secular terms do not appear in the case of the elements  $a_j$ , but are present in the right members of all the other elements.

The differential equations will now be integrated as power series in  $\mu$  and  $m_1, \dots, m_n$ . In order to simplify the details, suppose there are but two planets,  $m_1$  and  $m_2$ , and to abbreviate the notation let

$$\begin{aligned} h_1 &= x_1, & l_1 &= x_2, & h_2 &= x_3, & l_2 &= x_4, \\ p_1 &= y_1, & q_1 &= y_2, & p_2 &= y_3, & q_2 &= y_4. \end{aligned} \quad (44)$$

Then the differential equations become

$$\begin{aligned}
 \frac{da_i}{dt} &= m_2 f_i(a_1, a_2, \epsilon_1, \epsilon_2, x_i, y_i, t) & (i=1, 2, 3, 4) , \\
 \frac{d\epsilon_i}{dt} &= \sum_{j=0}^{\infty} g_{1j}(a_1, a_2, x_i, y_i) \mu^j + m_2 g_{0i}(a_1, a_2) + m_2 g_i(a_1, a_2, \epsilon_1, \epsilon_2, x_i, y_i, t) , \\
 \frac{dx_k}{dt} &= \sum_{j=0}^{\infty} \phi_{1kj}(a_1, a_2, x_i, y_i) \mu^j + m_2 \phi_{1k}(a_1, a_2, \epsilon_1, \epsilon_2, x_i, y_i, t) & (k=1, 2, 3, 4) , \\
 \frac{da_2}{dt} &= m_1 f_2(a_1, a_2, \epsilon_1, \epsilon_2, x_i, y_i, t) , \\
 \frac{d\epsilon_2}{dt} &= \sum_{j=0}^{\infty} g_{2j}(a_1, a_2, x_i, y_i) \mu^j + m_1 g_{02}(a_1, a_2) + m_1 g_2(a_1, a_2, \epsilon_1, \epsilon_2, x_i, y_i, t) , \\
 \frac{dy_k}{dt} &= \sum_{j=0}^{\infty} \phi_{2kj}(a_1, a_2, x_i, y_i) \mu^j + m_1 \phi_{2k}(a_1, a_2, \epsilon_1, \epsilon_2, x_i, y_i, t) .
 \end{aligned} \tag{45}$$

The functions  $\phi_{1kj}$  and  $\phi_{2kj}$  are homogeneous in  $x_i$  and  $y_i$  of degree  $j+1$ .

The solutions are to have the form

$$\begin{aligned}
 a_i &= \sum_{j_1, j_2=0}^{\infty} a_i^{(j_1, j_2)} \mu^{j_1} m_2^{j_2} & (i=1, 2) , \\
 \epsilon_i &= \sum_{j_1, j_2=0}^{\infty} \epsilon_i^{(j_1, j_2)} \mu^{j_1} m_2^{j_2} & (i=1, 2) , \\
 x_i &= \sum_{j_1, j_2=0}^{\infty} x_i^{(j_1, j_2)} \mu^{j_1} m_2^{j_2} & (i=1, 2, 3, 4) , \\
 y_i &= \sum_{j_1, j_2=0}^{\infty} y_i^{(j_1, j_2)} \mu^{j_1} m_2^{j_2} & (i=1, 2, 3, 4) ,
 \end{aligned} \tag{46}$$

where the  $a_i^{(j_1, j_2)}$ ,  $\epsilon_i^{(j_1, j_2)}$ ,  $x_i^{(j_1, j_2)}$ , and  $y_i^{(j_1, j_2)}$  are functions of the time to be determined. Substituting these expressions in (45), developing the right members, and equating corresponding powers of  $\mu m_1 m_2$ , it is found that

$$\begin{aligned}
 \frac{da_1^{(0,0)}}{dt} &= 0 , \\
 \frac{d\epsilon_i^{(0,0)}}{dt} &= g_{10}(a_1^{(0,0)}, a_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}) & (i=1, 2, 3, 4) , \\
 \frac{dx_k^{(0,0)}}{dt} &= \phi_{1k0}(a_1^{(0,0)}, a_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}) & (k=1, 2, 3, 4) , \\
 \frac{da_2^{(0,0)}}{dt} &= 0 , \\
 \frac{d\epsilon_i^{(0,0)}}{dt} &= g_{20}(a_1^{(0,0)}, a_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}) , \\
 \frac{dy_k^{(0,0)}}{dt} &= \phi_{2k0}(a_1^{(0,0)}, a_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}) ;
 \end{aligned} \tag{47}$$

$$\begin{aligned}
\frac{da_1^{(0,0)}}{dt} &= 0, \\
\frac{d\epsilon_1^{(0,0)}}{dt} &= \frac{\partial g_1}{\partial a_1} a_1^{(0,0)} + \frac{\partial g_1}{\partial a_2} a_2^{(0,0)} + \sum_{i=1}^4 \left[ \frac{\partial g_{1i}}{\partial x_i} x_i^{(0,0)} + \frac{\partial g_{1i}}{\partial y_i} y_i^{(0,0)} \right] + g_{10}(a_1^{(0,0)}, a_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}), \\
\frac{dx_1^{(0,0)}}{dt} &= \frac{\partial \phi_1}{\partial a_1} a_1^{(0,0)} + \frac{\partial \phi_1}{\partial a_2} a_2^{(0,0)} + \sum_{i=1}^4 \left[ \frac{\partial \phi_{1i}}{\partial x_i} x_i^{(0,0)} + \frac{\partial \phi_{1i}}{\partial y_i} y_i^{(0,0)} \right] \\
&\quad + \phi_{1k1}(a_1^{(0,0)}, a_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}), \\
\frac{da_1^{(0,1)}}{dt} &= 0,
\end{aligned} \tag{48}$$

$$\begin{aligned}
\frac{d\epsilon_1^{(0,1)}}{dt} &= \frac{\partial g_1}{\partial a_1} a_1^{(0,1)} + \frac{\partial g_1}{\partial a_2} a_2^{(0,1)} + \sum_{i=1}^4 \left[ \frac{\partial g_{1i}}{\partial x_i} x_i^{(0,1)} + \frac{\partial g_{1i}}{\partial y_i} y_i^{(0,1)} \right] + g_{10}(a_1^{(0,1)}, a_2^{(0,1)}, x_i^{(0,1)}, y_i^{(0,1)}), \\
\frac{dy_1^{(0,1)}}{dt} &= \frac{\partial \phi_1}{\partial a_1} a_1^{(0,1)} + \frac{\partial \phi_1}{\partial a_2} a_2^{(0,1)} + \sum_{i=1}^4 \left[ \frac{\partial \phi_{1i}}{\partial x_i} x_i^{(0,1)} + \frac{\partial \phi_{1i}}{\partial y_i} y_i^{(0,1)} \right] \\
&\quad + \phi_{1k1}(a_1^{(0,1)}, a_2^{(0,1)}, x_i^{(0,1)}, y_i^{(0,1)});
\end{aligned}$$

$$\begin{aligned}
\frac{da_1^{(0,2)}}{dt} &= 0, \\
\frac{d\epsilon_1^{(0,2)}}{dt} &= \frac{\partial g_1}{\partial a_1} a_1^{(0,2)} + \frac{\partial g_1}{\partial a_2} a_2^{(0,2)} + \sum_{i=1}^4 \left[ \frac{\partial g_{1i}}{\partial x_i} x_i^{(0,2)} + \frac{\partial g_{1i}}{\partial y_i} y_i^{(0,2)} \right], \\
\frac{dx_1^{(0,2)}}{dt} &= \frac{\partial \phi_1}{\partial a_1} a_1^{(0,2)} + \frac{\partial \phi_1}{\partial a_2} a_2^{(0,2)} + \sum_{i=1}^4 \left[ \frac{\partial \phi_{1i}}{\partial x_i} x_i^{(0,2)} + \frac{\partial \phi_{1i}}{\partial y_i} y_i^{(0,2)} \right], \\
\frac{da_2^{(0,0)}}{dt} &= f_2(a_1^{(0,0)}, a_2^{(0,0)}, \epsilon_1^{(0,0)}, \epsilon_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}, t),
\end{aligned} \tag{49}$$

$$\begin{aligned}
\frac{d\epsilon_2^{(0,0)}}{dt} &= \frac{\partial g_2}{\partial a_1} a_1^{(0,0)} + \frac{\partial g_2}{\partial a_2} a_2^{(0,0)} + \sum_{i=1}^4 \left[ \frac{\partial g_{2i}}{\partial x_i} x_i^{(0,0)} + \frac{\partial g_{2i}}{\partial y_i} y_i^{(0,0)} \right] \\
&\quad + g_{20}(a_1^{(0,0)}, a_2^{(0,0)}) + g_2(a_1^{(0,0)}, a_2^{(0,0)}, \epsilon_1^{(0,0)}, \epsilon_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}, t), \\
\frac{dx_2^{(0,0)}}{dt} &= \frac{\partial \phi_2}{\partial a_1} a_1^{(0,0)} + \frac{\partial \phi_2}{\partial a_2} a_2^{(0,0)} + \sum_{i=1}^4 \left[ \frac{\partial \phi_{2i}}{\partial x_i} x_i^{(0,0)} + \frac{\partial \phi_{2i}}{\partial y_i} y_i^{(0,0)} \right] \\
&\quad + \phi_{2k}(a_1^{(0,0)}, a_2^{(0,0)}, \epsilon_1^{(0,0)}, \epsilon_2^{(0,0)}, x_i^{(0,0)}, y_i^{(0,0)}, t);
\end{aligned}$$

$$\begin{aligned}
\frac{da_1^{(0,0,1)}}{dt} &= f_1(a_1^{(0,0,1)}, a_2^{(0,0,1)}, \epsilon_1^{(0,0,1)}, \epsilon_2^{(0,0,1)}, x_i^{(0,0,1)}, y_i^{(0,0,1)}, t), \\
\frac{d\epsilon_1^{(0,0,1)}}{dt} &= \frac{\partial g_1}{\partial a_1} a_1^{(0,0,1)} + \frac{\partial g_1}{\partial a_2} a_2^{(0,0,1)} + \sum_{i=1}^4 \left[ \frac{\partial g_{1i}}{\partial x_i} x_i^{(0,0,1)} + \frac{\partial g_{1i}}{\partial y_i} y_i^{(0,0,1)} \right] \\
&\quad + g_{10}(a_1^{(0,0,1)}, a_2^{(0,0,1)}) + g_1(a_1^{(0,0,1)}, a_2^{(0,0,1)}, \epsilon_1^{(0,0,1)}, \epsilon_2^{(0,0,1)}, x_i^{(0,0,1)}, y_i^{(0,0,1)}, t), \\
\frac{dx_1^{(0,0,1)}}{dt} &= \frac{\partial \phi_1}{\partial a_1} a_1^{(0,0,1)} + \frac{\partial \phi_1}{\partial a_2} a_2^{(0,0,1)} + \sum_{i=1}^4 \left[ \frac{\partial \phi_{1i}}{\partial x_i} x_i^{(0,0,1)} + \frac{\partial \phi_{1i}}{\partial y_i} y_i^{(0,0,1)} \right] \\
&\quad + \phi_{1k}(a_1^{(0,0,1)}, a_2^{(0,0,1)}, \epsilon_1^{(0,0,1)}, \epsilon_2^{(0,0,1)}, x_i^{(0,0,1)}, y_i^{(0,0,1)}, t),
\end{aligned} \tag{50}$$

$$\begin{aligned}
\frac{da_1^{(0,0,2)}}{dt} &= 0, \\
\frac{d\epsilon_1^{(0,0,2)}}{dt} &= \frac{\partial g_1}{\partial a_1} a_1^{(0,0,2)} + \frac{\partial g_1}{\partial a_2} a_2^{(0,0,2)} + \sum_{i=1}^4 \left[ \frac{\partial g_{1i}}{\partial x_i} x_i^{(0,0,2)} + \frac{\partial g_{1i}}{\partial y_i} y_i^{(0,0,2)} \right], \\
\frac{dy_1^{(0,0,2)}}{dt} &= \frac{\partial \phi_1}{\partial a_1} a_1^{(0,0,2)} + \frac{\partial \phi_1}{\partial a_2} a_2^{(0,0,2)} + \sum_{i=1}^4 \left[ \frac{\partial \phi_{1i}}{\partial x_i} x_i^{(0,0,2)} + \frac{\partial \phi_{1i}}{\partial y_i} y_i^{(0,0,2)} \right]; \text{ etc.}
\end{aligned}$$

The proof that the expansions lead to the precise terms written depends upon the form of the perturbative function when expressed in these variables, and it will be assumed here that it is known.

Consider the integration of equations (47), (48), (49), and (50). From the first and fourth equations of (47) it follows that  $a_i^{(0,0,0)}$  and  $a_i^{(0,0,0)}$  are constants, and from the principles of § 5 that they are the values of these variables at  $t = 0$ . It follows from the form of the secular part of the perturbative function that  $\epsilon_1$  and  $\epsilon_2$  are not involved explicitly in the right members of equations (47). Next consider the integration of the third and sixth systems of (47). They are linear with constant coefficients, and their integration presents no difficulties. The detailed discussion<sup>23</sup> shows that all of the roots of the characteristic equation are pure imaginaries with very small moduli. Consequently the  $x_i^{(0,0,0)}$  and the  $y_i^{(0,0,0)}$  are purely periodic with very long periods. These terms are precisely the ones found by Lagrange in his discussion of the secular variations.

Suppose the expressions for the  $x_i^{(0,0,0)}$  and the  $y_i^{(0,0,0)}$  are substituted in the right members of the second and fifth equations. They are reduced to quadratures and can be at once integrated, giving both secular and periodic terms for  $\epsilon_1^{(0,0,0)}$  and  $\epsilon_2^{(0,0,0)}$ . But  $\epsilon_1$  and  $\epsilon_2$  occur only in the combinations  $n_1 t + \epsilon_1$  and  $n_2 t + \epsilon_2$ , where  $n_1$  and  $n_2$  are the mean motions of the planets  $m_1$  and  $m_2$ ; therefore the secular terms in this element will produce no secular terms in the higher terms of the other elements.

Consider equations (48). It follows first that  $a_1^{(1,0,0)}$  and  $a_2^{(1,0,0)}$  are constants, and from the principles of § 5 that they are zero. The  $x_k^{(1,0,0)}$  and  $y_k^{(1,0,0)}$  are defined by linear non-homogeneous differential equations. The periods of the complementary functions, which are defined by the coefficients of the homogeneous parts, are the same as those of  $x_i^{(0,0,0)}$  and  $y_i^{(0,0,0)}$ . The functions  $\phi_{1k1}$  and  $\phi_{2k1}$  are homogeneous of the second degree in  $x_i^{(0,0,0)}$  and  $y_i^{(0,0,0)}$ . Therefore  $x_i^{(1,0,0)}$  and  $y_i^{(1,0,0)}$  will be purely periodic. The expressions for  $\epsilon_1^{(1,0,0)}$  and  $\epsilon_2^{(1,0,0)}$  are reduced to quadratures and contain purely periodic and secular terms.

Consider the integration of equations (49). In the first place,  $a_1^{(0,1,0)}$  is a constant which must be zero according to the principles developed in § 5.

The right member of the fourth equation, which defines  $a_2^{(0,1,0)}$ , is periodic, the time being involved in the form

$$\sin [i_1 (n_1 t + \epsilon_1) + i_2 (n_2 t + \epsilon_2)] , \quad (51)$$

where  $i_1$  and  $i_2$  are integers and  $n_1$  and  $n_2$  the undisturbed mean motions of the two planets. The time is also involved through  $\epsilon_1^{(0,0,0)}$  and  $\epsilon_2^{(0,0,0)}$ , each of which contains a secular term and series of periodic terms, as has just been seen, and through the  $x_i^{(0,0,0)}$  and  $y_i^{(0,0,0)}$  which enter in the coefficients of the sine functions. As has been shown, these variables are periodic with very long periods. Suppose the  $x_i^{(0,0,0)}$  and  $y_i^{(0,0,0)}$  are replaced by their trigonometric expressions, and let the powers of the cosines and sines be reduced to cosines and sines of multiples of the angles. These trigonometric functions will be multiplied by those of the type (51). Suppose the products are reduced to cosines and sines of the sums and differences. The final result will be purely periodic, unless the coefficients of  $t$  in some term derived from the  $x_i^{(0,0,0)}$  and  $y_i^{(0,0,0)}$  has the same numerical value as the coefficient of  $t$  in some term of the type (51). But the coefficients are very unequal in all the terms which have coefficients of sensible magnitude, and it would require particular values of the masses and the osculating  $a_i$ 's that this condition should be fulfilled for any term whatever. If it were fulfilled, a slightly different epoch could be taken, so that it would not be exactly fulfilled. Since the osculating elements cannot be exactly determined, it may always be supposed that the coefficients will in no case be numerically equal. This is somewhat similar to the assumption that there are no secular terms in the case of the element  $a$  in the ordinary method of treatment. It follows from this that  $a_2^{(0,1,0)}$  involves the time only under the cosine or sine function.

The equations which define the  $x_k^{(0,1,0)}$  and  $y_k^{(0,1,0)}$  are linear and non-homogeneous. The first

<sup>23</sup> See TISSERAND, *Mécanique céleste*, Vol. I, chap. xxiv.

terms of the right members are purely periodic, the same as in the case of the right member of the fourth equation. The complementary functions are the same, except for the constants of integration, as in the expressions for  $x_i^{(0,0)}$  and  $y_i^{(0,0)}$ . The particular integrals will be composed of terms of the same periods as those which appear in the first two terms in the right members. The complete integrals are the sums of the complementary functions and the particular integrals. The constants of integration are determined by the conditions that the  $x_i^{(0,1,0)}$  and  $y_i^{(0,1,0)}$  shall all vanish at  $t = 0$ .

Substituting the expressions for  $a_i^{(0,1,0)}$ ,  $x_i^{(0,1,0)}$ ,  $a_2^{(0,1,0)}$ , and  $y_i^{(0,1,0)}$  in the right members of the second and fifth equations, they are reduced to quadratures and can be at once integrated, giving both periodic and secular terms for  $\epsilon_i^{(0,1,0)}$  and  $\epsilon_2^{(0,1,0)}$ .

Equations (50) can be treated in a precisely similar manner, since they differ from (49) only by a permutation of the indices 1 and 2. If there are more than two planets, the right members of equations (49) and (50) contain more functions of the same type, one coming from each planet, and there is a set of equations similar to (49) and (50) for each planet.

The terms of the second order are the coefficients of  $\mu^2$ ,  $\mu m_1$ ,  $\mu m_2$ ,  $m_1^2$ ,  $m_1 m_2$ , and  $m_2^2$ . It is possible to determine the character of these terms without writing out explicitly the differential equations by which they are defined. It will be convenient to have the results already attained stated together for reference.

$a_1^{(0,0,0)}$  and  $a_2^{(0,0,0)}$  are constants, the values of the major semi-axes at  $t = 0$ .

$x_i^{(0,0,0)}$  and  $y_i^{(0,0,0)}$  are purely periodic, with very long periods.

$\epsilon_1^{(0,0,0)}$  and  $\epsilon_2^{(0,0,0)}$  contain both periodic and secular terms.

$a_1^{(1,0,0)}$  and  $a_2^{(1,0,0)}$  are zero.

$x_i^{(1,0,0)}$  and  $y_i^{(1,0,0)}$  contain only periodic terms.

$\epsilon_1^{(1,0,0)}$  and  $\epsilon_2^{(1,0,0)}$  contain periodic and secular terms.

$a_1^{(0,1,0)}$  is zero.

$a_2^{(0,1,0)}$  contains only purely periodic terms.

$x_i^{(0,1,0)}$  and  $y_i^{(0,1,0)}$  contain only periodic terms of two types, short-period terms and very long-period terms.

$\epsilon_1^{(0,1,0)}$  and  $\epsilon_2^{(0,1,0)}$  contain both purely periodic and secular terms.

$a_1^{(0,0,1)}$  contains only purely periodic terms.

$a_2^{(0,0,1)}$  is zero.

$x_i^{(0,0,1)}$  and  $y_i^{(0,0,1)}$  contain only periodic terms of two types, short-period terms and very long-period terms.

$\epsilon_1^{(0,0,1)}$  and  $\epsilon_2^{(0,0,1)}$  contain both purely periodic and secular terms.

Consider the coefficients of  $\mu^2$ . It follows from (45), and the fact that all these coefficients must vanish at  $t = 0$ , that  $a_1^{(2,0,0)} = a_2^{(2,0,0)} = 0$ . The  $x_i^{(2,0,0)}$  and  $y_i^{(2,0,0)}$  are defined by linear non-homogeneous differential equations. The non-homogeneous parts contain periodic terms, some of whose periods are the same as in the complementary functions. Consequently the  $x_i^{(2,0,0)}$  and  $y_i^{(2,0,0)}$  contain purely periodic and Poisson terms, and  $\epsilon_1^{(2,0,0)}$  and  $\epsilon_2^{(2,0,0)}$  contain periodic, Poisson, and secular terms. The character of the coefficients of the other terms of the second order can be determined in the same manner. It would be of no value to write them out here.

The results which have been obtained are as follows: The major axes have no secular or Poisson terms of the first order, and the periodic terms are all of short period, except the usual long-period terms. The  $x_i$  and  $y_i$  of order zero and one contain only purely periodic terms. The terms of order zero are precisely the very long-period terms found by Lagrange. The periodic terms of the first order are of two classes, the very long-period terms and the short-period terms. The latter are not precisely those found in Lagrange's theory, for their periods have been modified a very little by the very long-period terms. If the Lagrangian method is valid at all, its realm of validity is almost certainly much more restricted than that of this method. The short-period terms in the Lagrangian

method are computed with the osculating elements in the right members. Suppose now the lines of nodes and lines of apsides actually rotate as the terms of order zero indicate. The result will be that when half revolutions have been performed the Lagrangian short-period terms will be precisely opposite to what they should be, and it is very doubtful whether the whole process converges for such a time. On the other hand, the slight corrections to the periods introduced by the methods given here exactly take into account the effects of these rotations, so that the short-period terms are nearly correct for very long intervals of time. For short intervals of time the two methods give sensibly the same results up to the terms of the second order. That it is not necessary to take into account the relations of the nodes and apsides for practical purposes follows only from the fact that the motions are so slow that they do not affect the perturbations sensibly for a long time. However, in the case of the moon, where the corresponding motions are very rapid, they have been included by nearly every lunar theorist.<sup>24</sup> The case is not fundamentally different from this, although the artifices employed to accomplish the results are entirely distinct. Thus this method leads to terms of the same form as found by Lagrange, it is proved to be valid for a positive finite interval of time, and the period for which it is valid is probably much longer than that of the method of Lagrange, if, indeed, it is possible to make the latter the first step in a general process which converges for any value of the time.

It is seen that the Poisson and secular terms appear in the terms of higher order, so that even the form of the solutions does not apparently indicate stability. The conclusion is certain that there are at present no mathematical proofs of the permanent stability of the solar system, although the results given here prove that the present general configurations will be changed very slowly, if at all. The problem awaits further perfection of mathematics, and the fact that the initial conditions cannot be exactly determined may perhaps render the problem of stability forever incapable of solution, just as it is impossible to decide whether the major axes have secular terms of the first order, because it cannot be determined whether the mean motions are exactly commensurable or not.

#### §8. THE METHOD OF SMALL VARIATIONS

Suppose the solutions of a system of differential equations can be found for particular initial conditions. Then, if the actual initial conditions differ only a little from the particular ones, the actual co-ordinates will differ only a little from those given by the first solution, at least for a time. The method of finding the deviations from solutions defined by particular initial conditions will be termed, for convenience, the method of small deviations. It remains to be shown that under certain conditions these small deviations can be represented by convergent power series within certain time limits.

Suppose the differential equations to be solved are

$$\frac{dx_i}{dt} = X_i(x_1, \dots, x_n, t) \quad (i=1, \dots, n), \quad (52)$$

Suppose it is known in some way that for  $x_i = x_i^{(0)}$  as initial conditions the solutions of (52) are

$$x_i = f_i(t) \quad (i=1, \dots, n), \quad (53)$$

which will be supposed to be valid for all  $t$  equal to or greater than zero and less than  $T$ . Suppose the actual initial values of the co-ordinates are  $x_i^{(0)} + \epsilon a_i$ , where the  $a_i$  are small and  $\epsilon$  is a parameter which is to be put equal to unity in the final results. Let the values of the co-ordinates under these conditions be

$$x_i = f_i(t) + \epsilon \xi_i \quad (54)$$

<sup>24</sup> See BROWN, *Lunar Theory*, p. 52.

where the  $\xi_i$  are the corrections to be determined. Substitute (54) in (52) and expand in powers of  $\xi_j$ , and it will be found that

$$\epsilon \frac{d\xi_i}{dt} = \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} \epsilon \xi_j + \text{higher powers in } \epsilon \xi_j \quad (55)$$

whose coefficients depend on the partial derivatives of  $X_i$  with respect to  $x_j$ . Suppose that for  $\xi_j = a_j$  the right members of (55) converge for  $0 \leq t < T$ .

Consider the integration of equations (55) as power series in the parameter  $\epsilon$ . These equations fulfil all the conditions imposed upon those treated in § 5; consequently the solutions may be represented by series of the form

$$\xi_i = \sum_{j=0}^{\infty} \xi_i^{(j)} \epsilon^j, \quad (56)$$

where  $\xi_i^{(j)}$  are functions of  $t$ , and where the series (56) converge for all  $0 \leq t < t_0$ , where  $t_0$  is a positive number. In general, the smaller the differences between the particular initial conditions giving the solutions (53) and the actual initial conditions, the larger is the value of  $t_0$ .

Suppose the solutions (53) are periodic and valid for all finite values of the time. Then the equations determining the deviations of the first order from the periodic solution are

$$\frac{d\xi_i^{(1)}}{dt} = \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} \xi_j^{(1)} \quad (i=1, \dots, n), \quad (57)$$

where the coefficients of this linear homogeneous system are periodic functions. The solutions of this system will be periodic with the period depending on the coefficients and period of  $\frac{\partial X_i}{\partial x_j}$ . If these partial derivatives contain a constant term, as they do in most practical problems, and if the coefficients of the periodic terms involve powers of a small parameter  $m$ , then the period of the solutions of (57) will differ from that which would be obtained by neglecting the periodic terms by powers of  $m$ .

The deviations of the second order are determined by the equations

$$\frac{d\xi_i^{(2)}}{dt} = \sum_{j=1}^n \frac{\partial X_i}{\partial x_j} \xi_j^{(2)} + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \frac{\partial^2 X_i}{\partial x_j \partial x_k} \xi_j^{(1)} \xi_k^{(1)}, \quad (58)$$

which are linear, but not homogeneous. If any second term in the right member contains an expression of the same period as the  $\xi_j^{(1)}$  would have without the non-linear part, then the solutions for  $\xi_i^{(2)}$  will contain Poisson terms; otherwise the  $\xi_i^{(2)}$  will be periodic. If Poisson terms enter in the  $\xi_i^{(1)}$ , then the  $\xi_i^{(2)}$  will, in general, contain secular terms and terms of the type  $c_1 t \frac{\sin}{\cos}(c_2 t + c_3)$ . The higher terms will, in general, contain secular terms of higher degree and Poisson terms containing higher powers of  $t$  in their coefficients. Although this method gives rise to such terms, it neither shows that it is not valid nor that the motion under consideration is unstable; all that can be said is that it is valid if the time interval is not taken too great.

Instead of determining the deviations from particular solutions of the general differential equations, which in general can be found only with great difficulty, certain terms in the right members may be omitted until the variations from the approximate motion are computed. Suppose the differential equations of motion are

$$\frac{dx_i}{dt} = X_i + \sum_{j=1}^n X_i^{(j)} \mu^j \quad (i=1, \dots, n), \quad (59)$$

where  $\mu$  is a parameter. Suppose that the right members are convergent power series when the  $x_i$  have their initial values for  $0 \equiv t < T$ .

Suppose the differential equations

$$\frac{dx_i}{dt} = X_i^{(0)} \quad (i=1, \dots, n) \quad (60)$$

are integrated, giving for the particular initial conditions  $x_i = x_i^{(0)}$  the periodic solutions

$$x_i = f_i(t), \quad (61)$$

valid for all finite values of the time.

Suppose the actual initial values of the variables  $x_i = x_i^{(0)} + \epsilon a_i$ , where the  $a_i$  are small and  $\epsilon$  is a parameter which is to be put equal to unity in the final result. The actual co-ordinates at any time are

$$x_i = f_i(t) + \epsilon \xi_i, \quad (62)$$

where the  $\xi_i$  are unknown functions of the time to be determined. For this purpose substitute equations (62) in (59) and develop the right members as power series in  $\epsilon$  and  $\mu$ . These series will converge for sufficiently small values of  $\xi_i$  and  $\mu$ , if the  $X_i^{(j)}$  are analytic functions of the  $x_i$  and regular for  $x_i = x_i^{(0)}$ , while  $t$  varies from 0 to  $T$ . These conditions will always be fulfilled in the problems in which practical applications of this method would be desirable. After these transformations the differential equations become

$$\frac{d\xi_i}{dt} = \sum_{j,k=0}^{\infty} X_i^{(j,k)} \xi^k \mu^j \epsilon^k \quad (i=1, \dots, n). \quad (63)$$

In accordance with the principles of § 5, these equations can be integrated as power series in  $\mu$  and  $\epsilon$  which converge for  $0 < t < t_0$ , the value of  $t_0$  depending on the coefficients of the differential equations, the  $a_i$  and  $\mu$  and  $\epsilon$ . As in the preceding case, Poisson and secular terms will, in general, appear in the higher terms when the integration is carried out in this manner.

Hill's method of treating the lunar theory is in its essential features in agreement with the processes which have just been explained. He neglected in the right members of the differential equations all terms containing the latitude of the moon, the eccentricity of the sun's orbit, and the ratio of the distance of the moon from the earth to that of the sun—quantities which play the rôle of parameters, and then found periodic solutions of the resulting differential equations by properly determining the initial conditions. These solutions which give the variational orbit correspond to equations (61). They were found with rare ingenuity and great precision by Hill.<sup>25</sup> The part of the motion of the perigee depending on the ratio of the mean motions of the sun and moon and on the first power of the eccentricity of the moon's orbit was also found by Hill<sup>26</sup> with great accuracy. This motion introduces changes in the variational co-ordinates. The corresponding terms in this method are obtained by letting in the solutions of (63), which are of the form

$$\xi_i = \sum_{j,k=0}^{\infty} \xi_i^{(j,k)} \mu^j \epsilon^k, \quad (64)$$

$j=0$  and  $k=0$ . The differential equations which define these terms are

$$\frac{d\xi_i^{(0,0)}}{dt} = X_i^{(0,0)} \xi^{(0,0)}, \quad (65)$$

where the  $X_i^{(0,0)}$  are periodic functions of the time. The solutions of this linear system are periodic with a period whose difference from that of the  $X_i^{(0,0)}$  gives this part of the motion of the perigee.

<sup>25</sup> *American Journal of Mathematics*, Vol. I.

<sup>26</sup> *Acta Mathematica*, Vol. VIII.

The higher approximations have to a considerable extent been carried out by Brown, but the method of solution is somewhat different from that outlined here. The form of the solutions is assumed, or rather inferred from the investigations of earlier linear theorists, the final results being expressed as purely periodic series. There is little doubt that, from a practical point of view, this is more satisfactory than any scheme identifying Poisson and secular terms with coefficients of low order in the parameter, but the assumption involved is unjustified, and the series obtained are very probably divergent in the mathematical sense.

There seems to be some hope in the plan of finding a more exact periodic solution than the variational orbit, depending, of course, upon particular initial conditions, one which includes more of the right members of the differential equations, and then computing the deviations from this orbit. In this manner satisfactory expressions might be obtained which are rigorous for a long interval of time.<sup>1</sup>

<sup>1</sup>See J. J. van der Willigen, *ibid.* p. 42.

RADIAL VELOCITIES OF TWENTY STARS



# RADIAL VELOCITIES OF TWENTY STARS HAVING SPECTRA OF THE ORION TYPE

EDWIN B. FROST AND WALTER S. ADAMS

## INTRODUCTION

THE determination of the velocity of a star in the line of sight according to Doppler's principle was first attempted by Huggins in 1868. His observations were followed by those of Vogel three years later, and the validity of the method may be considered to have been established by these investigations, together with others dealing with the motions of planets and the rotation of the Sun. Visual observations of the displacements of the lines in stellar spectra from the positions of corresponding lines in the spectrum of a vacuum tube are, however, of extreme difficulty, and measurements which can be regarded as at all accordant are only possible with the most powerful telescopes and the brightest stars. It was not until the photographic method was applied to this class of observations by Vogel in 1887 that results of an accurate character were obtained. The determinations of the radial velocities of fifty-one stars by Vogel and Scheiner, described in detail in the seventh volume of the *Publicationen des Astrophysikalischen Observatoriums zu Potsdam*, constitute the foundation of the modern methods of observing stellar motions in the line of sight.

The next great advance was made by Campbell in his design of and work with the Mills spectrograph of the Lick Observatory, described in the *Astrophysical Journal*, Vol. VIII (1898), pp. 123-56. The use of iron as a comparison spectrum (previously tried by Vogel and by Deslandres, but not regularly employed by them), together with the closest attention to the optical and mechanical construction of the instrument and great refinement in the measurement of the plates, enabled Campbell to increase greatly the accuracy of the determinations, so that the natural unit became the kilometer per second, instead of the sevenfold greater German geographical mile employed by Vogel.

The necessity for the greatest attainable rigidity of the spectrograph, to prevent flexure, and for the maintenance of the prisms at a constant temperature, became apparent from the experience of all observers engaging in spectrographic work, and has led to further improvements in the current type of spectrograph, and tended to increase still further the precision of measurements of radial velocities. The observations given in the present paper constitute a part of the first year's work with the Bruce spectrograph of the Yerkes Observatory, which was completed in the autumn of 1901, and has since then been systematically used in determining stellar motions in the line of sight.

The spectra of the *Orion* type are of an especial interest to the astrophysicist, as they seem unquestionably to occupy a position very early in the scale of stellar evolution. Their chemical constitution is simple, the chief elements showing lines being hydrogen, helium, oxygen, silicon, nitrogen, and magnesium. The presence of helium is the principal characteristic of the type, whence they are frequently called helium stars. The broad and diffuse nature of most of the lines in these spectra renders them less adapted to precise measurement for radial velocity; moreover, the dispersion of the Bruce spectrograph is rather high for such lines, so that it is quite out of the question to expect any such accuracy in the determined velocities as may be obtained for stars of the solar type. A judgment as to the accuracy reached with this instrument, and with the methods employed in measuring and reducing the plates, should be based upon the results given in the section on the control plates of the Moon, planets, and certain standard stars of the solar class (pp. 18-32). The optical features of the Bruce spectrograph were especially planned, however, to cover a region of spectrum not naturally included by most of the large spectrographs engaged in line of sight work, and this region (centering near the strong helium line at  $\lambda 4471$  and the characteristic magnesium line at  $\lambda 4481$ ) was chosen as

particularly well suited for work on stars of the *Orion* type. These stars, furthermore, have hitherto been little observed for radial velocity, so that the field is a comparatively open one. The twenty stars included in this paper were not chosen by any definite principle of selection, but merely represent those stars of which three or more spectrograms have been obtained during the past year, from an observing list of something over one hundred stars shown to be of the *Orion* type by the investigations of Vogel and Wilsing.<sup>1</sup> But stars of this type previously known to be spectroscopic binaries, and those which have been found to be such during the progress of this work, have been excluded from the list. These last named are six in number, and will be discussed in due time elsewhere.

### INSTRUMENTS

The Bruce spectrograph was designed and largely constructed at the Observatory, with funds provided by the late Miss Catherine W. Bruce, of New York city, amounting to twenty-three hundred dollars, supplemented by a grant of five hundred dollars from the Rumford fund of the American Academy of Arts and Sciences. As a detailed description of the spectrograph has already been published,<sup>2</sup> it will be necessary to recall here only some of the essential features of the instrument and its use in connection with the great Yerkes refractor. A correcting lens of 57 mm. aperture is placed in the cone of rays from the forty-inch objective, at a distance of about 100 cm. from the slit, and unites the rays so that the spectrum of a star is of uniform width for about 100 tenth-meters on either side of  $\lambda 4500$ .

The triple collimating lens, of 51 mm. aperture and 958 mm. focus, was replaced during the year by a quadruple "isokumatic" lens, designed by Professor Hastings, which was originally ordered but could not then be supplied. The new collimator is of the same aperture and focus, and slightly increases the field of good definition, which was already quite satisfactory.

The three prisms are of specially annealed Jena glass, figured by Brashear, and have angles of  $61^{\circ} 34'$ , with an index for  $\lambda = 4500$  of  $n = 1.6724$ . Their size is such as to transmit the full beam from the collimator of 51 mm. diameter, with allowance for the increased size of the beam after dispersion in the first and second prisms.

Two cameras are provided with the instrument; A, a Zeiss anastigmat of 71 mm. aperture and 449 mm. focus; and B, a Hastings triple of 76 mm. aperture and 607 mm. focus. The two series of plates taken with the spectrograph are designated as A and B according to the camera lens employed. The range of fair focus is somewhat greater in (tenth-meters) for the shorter camera, but the superior scale of camera B gives it the advantage in the range covered. The photographic "speed" of the two cameras is practically identical: the same exposure-time is required for the same object under equal atmospheric conditions. We account for this unexpected circumstance by the losses of light on passing through the five component lenses of the anastigmat.

Camera B has given us serious trouble by becoming astigmatic at intervals, without any known cause external to the lens. We have attributed this to strain produced by the cement (balsam), and the notes under the "journal of observations" show that the lens has been several times recemented by the maker. When a trial plate shows any defective performance of camera B (commonly fringes on the sides of the comparison lines), camera A is always used. It should be mentioned here that we find it much more accurate and satisfactory to test a lens by photographing the emission lines from metallic electrodes rather than the absorption lines of the solar spectrum. Of the plates referred to in this paper fifty-four have been taken with A and eighty-two with B.

The principal changes which have been made in the instrument since the descriptive article was written (in December, 1901) for the *Astrophysical Journal* (*loc. cit.*) are the following:

<sup>1</sup> Vogel and Wilsing, "Die Spectra von 305 Sternen," *Zeitschrift für Astrophysik und verwandte Gebiete*, Bd. VII, Heft II.

<sup>2</sup> EDWIN B. FROST, "The Bruce Spectrograph of the Yerkes Observatory," *Astrophysical Journal*, Vol. XV (1902), pp. 1-27.

The bar containing the windows, which determine the length of slit used at a given exposure (a single window for the star-light, a double window for spark-light), has been placed slightly in front of the slit instead of behind it, as formerly. This made the tips of the spark lines much sharper than they had been previously.

To insure the full and uniform illumination of the collimator lens by the light from the source of comparison spectrum, two changes and two additions have been made. The use of the concave mirror to project the image of the spark or tube upon the slit has been abandoned, as the electrodes themselves cut out an appreciable amount of the cone from the mirror, and admitted the possibility of non-uniform illumination of the collimator. The simple biconvex lens originally provided as an alternative has been regularly used for all of the later plates described in the journal of observations.

The plane silvered mirror at first used to reflect the comparison light  $90^\circ$  downward into the slit has been replaced by a diagonal prism.

A small ground glass diffusing screen has been mounted 20 mm. in front of the slit, and is turned into position when the comparison spectrum is being photographed. This should insure a uniform source filling a much larger angle than that subtended at the distance of the slit by the collimating lens, and it has proved entirely satisfactory. The idea was taken from the Potsdam spectrograph, where a ground glass screen diffuses the light from the arc lamp which there serves as the source of the comparison spectrum.

For testing the illumination of the collimator Campbell's practice has been followed of placing a photographic plate in a small holder directly over the aperture of the lens. The exposure is then made to the light of the spark. The negative gives a much more satisfactory test of the illumination than is possible by the usual visual method.

The method of guiding during the exposure on the star, by the light reflected from the symmetrically inclined slit-jaws, has proved very satisfactory. When desired, the observer can, by simply turning a pinion, throw into the guiding telescope the light of the star or spark reflected at the first surface of the first prism. The method thus combines the advantages of the methods of Huggins and of Vogel.

The temperature case which envelopes the whole spectrograph has also given entire satisfaction in its operation. Although the electric heating is not automatic, it has not been found too much of an inconvenience for the observer to read the thermometers from time to time during an exposure, and to turn on the current as necessary. A change of  $1^\circ\text{C}$ . in the temperature within the outer case usually causes a change of about  $0.1$  within the inner case (prism-box).

#### THE PLATES OF SPECTRA

The dispersion and scale of the plates for cameras A and B are as follows:

WAVE- LENGTH	ANGULAR DIS- PERSION FOR ONE-TENTH METER	TENTH-METERS PER MM.	
		Camera A	Camera B
4300	45.7	10.0	7.4
4500	33.8	13.5	10.1
4700	26.0	17.6	13.1

A test of the practical separation of close lines in the solar spectrum, photographed on fine-grained plates, gave almost identical results with those described for the Mills spectrograph and the largest Potsdam spectrograph. On the fastest plates, which are used for stellar spectra, the least separable distance is of course less, and is about 0.2 tenth-meters at the center of the plate ( $\lambda$  4480).

The range of spectrum in sufficiently sharp focus for determining displacements for velocities is

on properly exposed plates—for Camera A, from about  $\lambda$  4300 to  $\lambda$  4700; for Camera B, from about  $\lambda$  4340 to  $\lambda$  4700. For merely qualitative work, the range usable would be considerably greater.

The plates used were Seed's "Gilt Edge" 27, and Cramer's "Crown." At the close of the period covered here Seed's double-coated, non-halation plates were tried, with very satisfactory results. The size of the negatives is  $1\frac{3}{8}$  in.  $\times$  4 in. ( $42 \times 102$  mm.). The developer employed was rodinal or hydrochinon, commonly the former.

*Comparison spectrum.*—The rotating drum of the spark apparatus provides for the use of three metallic electrodes and a vacuum tube. On the plates discussed in this paper we have always employed titanium, and sometimes, in addition, iron or chromium electrodes, or the helium tube (which contains hydrogen as an impurity and gives also the hydrogen lines). We have used titanium in preference to iron for the standard comparison spectrum for the past three years, and obtain with it sharper and more numerous lines in the region of spectrum covered than with iron. In order to suppress the air lines when iron is used, a small self-induction coil was constructed in 1899 by Leeds & Co., of Philadelphia, according to specifications of Frost. It has an outer diameter of about 40 mm. and a length of about 42 cm. and is separated into sections with binding posts, so that 50, 100, 200, or 500 turns, or any combination of them, may be used. There is no core. The coils are insulated in the same manner as for the secondary of an induction coil. The air lines with the iron spark are greatly cut down when fifty turns are used, and can be entirely suppressed with a greater number of turns. The lines of the other metallic spectra are also rendered sharper by the use of the self-induction.

The current for the primary of the induction coil furnishing the current for the spark is taken from the 110-volt mains, and is reduced by properly arranged resistance coils so that from four to fourteen volts can be tapped off. The induction coil is stationary, and the secondary current is carried in an excellent cable, reaching the spectrograph in any position of the telescope with comparatively little loss of potential.

#### MEASURING MACHINES

All our measurements of spectra were formerly made with the familiar Zeiss comparators, having two microscopes, one for the negative and the other for the graduated scale. While these instruments are excellent, and have the advantage of depending upon an invariable scale instead of a screw, they are nevertheless rather slow in action, and the eye is strained in alternating between the microscopes with their different degrees of illumination of field. In 1904 two screw machines were therefore ordered from William Gaertner & Co., of Chicago, according to specifications by Professors Hale and Frost, and they have been almost exclusively used in the measurements covered by this paper. An idea of the instrument may be gained from the accompanying plate. The box casting is 23 cm. long, 8.5 cm. wide, and 5 cm. deep. To this the microscope is attached at an angle convenient for observing. The stage or plate-carriage moves in accurately figured ways on a second carriage which moves with the nut of the micrometer screw. The stage may be unclamped from the lower carriage and may be rapidly moved in a direction accurately parallel to the axis of the screw, through a distance of 40 mm. This allows the plate to be quickly aligned under the microscope, and to be rapidly examined before it is measured. A fine screw at the observer's left permits a slight adjustment of the position of the stage after it is clamped to the lower carriage. Thus the stage may be set so that any desired reading of the micrometer screw will correspond to a given position on the plate. The screw is of 10 mm. diameter and 10 cm. length, with a pitch of one-half millimeter. Great care was given by Mr. Gaertner to its construction. The nut is 28 mm. long. A weight attached to it by a light wire over a pulley not shown in the figure removes the small amount of lost motion otherwise present. The screw head is 80 mm. in diameter and is graduated with 500 divisions, so that 1 division = 0.001 mm. or 1 micron ( $\mu$ ). Every tenth division is doubly numbered, *e. g.*, as 39 and 89, so that the readings can be taken off the head directly for a whole millimeter instead of a half (one revolution).

Whole millimeters are read from a scale along the ways of the carriage. The microscopes are from Zeiss, and have the valuable feature of a variable magnification (ranging from about six to thirty diameters) as the objective is moved along a graduated scale. The reticle was ruled on glass at the observatory, and consists of a single fine line and a close pair. There is also provided an eye-piece micrometer which is not used. The whole eye end, including the reticle, can be slightly rotated so that the lines can be made perpendicular to the motion of the screw.

#### METHOD OF MEASUREMENT

After the negative has been aligned so that the edge of the spectrum moves along some mark or dust particle in the field, the upper carriage or stage is moved so that any desired value is given to the initial setting, and is then clamped, after which it is moved only by the screw. We commonly first place the plate on the stage so that the violet end of the spectrum will appear toward the left in the microscope, when the micrometer settings will increase with the wave-lengths. Four settings are then made on each star line, alternating each time in the direction from which the line is brought under the "thread" of the reticle. Four settings are also made on each comparison line, two each on the portions of the comparison line above and below the star spectrum, with the same alternation in the direction of approaching the thread. Care is taken that there shall be no change in the illumination of the plate during the measurement, and the mirror is rarely touched between plates. A change in the angle of the mirror during measurement would be likely to produce a noticeable shift in the apparent position of the lines.

The point in the comparison line (dark on the negative) at which the line is bisected by the thread may be different according to the practice of different observers. Thus it is the habit of Frost to make the setting at a point one-third of the length of the comparison line away from its inner end; while Adams makes his settings on the inner tips of the comparison lines. On star lines, of course, the setting is always made at the center. The correction for curvature will therefore be regularly different for the two observers. In case of very strong comparison lines, the accuracy of the settings may be somewhat increased by the use of the double thread of the reticle, but this has been very seldom done in these measures. The single thread is invariably the more suitable for the star lines (white on the negative).

After the plate has been measured in one position it is reversed on the stage so that the violet end will appear toward the right in the microscope, and the micrometer readings will decrease with increasing wave-lengths. The new position is so adjusted that the readings will add up some convenient number of whole millimeters when combined with the corresponding readings for the previous position of the plate. If this whole number is 80, then the averages of the four settings in the second position of the negative will be successively subtracted from 80.0000, and the remainder will be very closely equal to the previous average, with which it is now combined to form the Mean of the Settings. If the measurements in the two directions are not made consecutively, the observer is careful to see that the second measure is made when the comparator is at the same temperature as at the first measure.

It should be understood that the measurement of a plate in each position is a single, homogeneous process, yielding results which may be considered absolute, within the limits of error involved. That is, the settings are not first made on a star line and then on a comparison line as a pair, giving a differential value of the distance between the two; but the settings are progressively made along the plate until the whole measurement is complete for that position on the stage. The question of the choice of lines to be measured is taken up in the next section.

1. *Length of lines (width of spectrum).*—Two sets of windows have been used during the year, each set yielding a different length of lines (both star and spark) for the two cameras. With the narrower windows the length of the lines of both star and comparison spectrum is 0.17 mm. for camera B, and 0.13 mm. for camera A; with the larger windows, which have been used almost exclusively since

October 31, 1901, the length is 0.40 mm. for camera B, and 0.29 mm. for camera A. With average conditions of atmospheric steadiness, it is necessary during the exposure to move the star image back and forth through a small amplitude on the slit by the electric slow-motions, in order that the width of the star spectrum may correspond to the full width of the window. On faint stars the star spectrum is usually kept somewhat narrower than the full width, thus diminishing the necessary exposure time.

2. *Curvature of the lines.*—Correction is made for the curvature of the comparison lines by means of tables computed by Ditscheiner's formula, which has been shown by Adams to be accurate for long slits. The amount of the correction ( $x$ ) is indicated for the two cameras by the following extracts from the tables. The distance from the center of the star lines to the point for which the correction applies is denoted by  $z$ :

	Camera A $x$	Camera B $x$
0.10 mm.	0.00008 mm.	0.00006 mm.
.20	.00032	.00024
.30	.00072	.00054
.40	.00128	.00096
.50	.00208	.00149

This table is calculated for an index of refraction in the prism of  $n = 1.6724$  for  $\lambda 4500$ . The difference is insensible in practice for other wave-lengths in the range of good focus of our plates.

#### METHOD OF REDUCTION

The fundamental principle of the method adopted here for the measurement and reduction of line of sight plates is that each negative shall be treated solely by itself and wholly independently of any other plate. This assumes that there is on each plate a sufficient number of well-defined comparison lines whose wave-lengths are accurately known, so that the wave-length of any point in that stellar spectrum can be determined with all necessary precision. Hence no corrections have to be applied on account of the temperature of the instrument at the time the plate was made, or to reduce the plate to the scale of some standard solar or metallic spectrum plate. It may be objected that with so stable an instrument as the Bruce spectrograph, the dispersion formula should be the same for all plates taken at the same temperature; hence always for the whole series of plates taken on a given night. This is readily admitted, but in practice the time spent in computing the Hartmann dispersion formula for each plate, with the use of the "Brunsviga" calculating machine, is no greater than that spent in adapting to a given formula the micrometer settings for each plate.

The three lines of the comparison spectrum taken for the standards in determining the constants,  $s$ ,  $c$ , and  $\lambda_c$ , of the simple Hartmann formula

$$\lambda - \lambda_c = \frac{c}{s - s_c}$$

are selected on the basis of their sharpness on the negative and their proper spacing near the two extremities and center of the measured portion of the plate. The correction for curvature is first applied to the mean of the eight settings on each of the lines of the comparison spectrum. (In some cases the correction for curvature has been applied in kilometers to the final mean of the radial velocities determined from the different star lines.) Then the wave-lengths of all the lines measured in both star and comparison spectrum are computed by the formula. In making the measurements the best (most sharply defined, and for solar stars simplest) star lines were selected, without reference to their occur-

rence in the comparison spectrum, provided only that their wave-lengths in the laboratory or in the solar spectrum are known. In every case where possible the nearest good comparison line to the selected star line is also measured. The second column of the detailed measurements, pp. 18 ff. and 33 ff., contains the computed wave-lengths. The differences between these computed values and the known wave-lengths of the comparison lines (as given in Rowland's tables for the solar spectrum) are now given in the third column as "Correction to Comp. Lines." Aside from the accidental errors of the settings, these indicate the departure of the formula from an exact representation of the wave-lengths. The corresponding corrections for the intervening star lines are interpolated between the appropriate values for the adjacent comparison lines, and are given in the fourth column.

The fifth column is entitled "Wave-length in Sun" in the case of plates of the Moon and solar stars, and is taken directly from Rowland's table. Where it is evident that two (or more) solar lines, too close to be separated by the spectrograph, have blended together in forming the line seen on the plate, the wave-length given is the result of the combination of Rowland's values of the constituent lines, with weights proportional to the estimates of their intensities in Rowland's table. A list is given below of the blends thus formed which occur in these measures.

In case of the stars of the *Orion* type the fifth column is entitled "Normal Wave-Length," and gives the best values we have been able to find for the laboratory or other determinations of the wave-lengths of the lines in question. Details as to these lines and the authorities for the wave-lengths are also given below.

The next column contains the displacement, or difference between the normal wave-length and the measured wave-length, after the latter has been corrected by the amount given in the fourth column. From the displacement the corresponding radial velocity for each star line is readily determined from our tables, computed with a value of the velocity of light of 299,860 km. per second.

In the case of stars of the *Orion* type, where the stellar lines vary greatly in their degree of diffuseness and consequent difficulty of accurate bisection, the observer assigns an arbitrary weight to the lines, which is given in the last column of the tables of measures. This weight is not assigned after an examination of the accordance of the settings, but commonly immediately upon making the first setting, and it represents the relative certainty that the observer felt as to his estimate (*Auffassung*) of the center of the line. When the observer gave a different estimate of weight in the two positions of the plate (violet toward left and violet toward right), the lower weight was taken. Inasmuch as the *Auffassung* is for such ill-defined and diffuse lines wholly a matter of individual psychology and physiology, the weights assigned to the same line on the same plate by the two observers may differ very considerably. To the same line on different plates of the same star quite different weights may be given by the same observer, since the conditions of exposure and development, and consequent intensity of the negative, never repeat themselves precisely.

The weighted mean of the determinations of velocity for all the lines is used as the radial velocity from that plate by that observer, but the unweighted mean is also given, for comparison, at the foot of column 7. These means were taken on the original reduction sheets where the computations were carried to 0.01 km., and hence may differ slightly from the means of the values when rounded to tenths as printed. Where several star lines could be measured, the difference between the weighted and simple mean is slight.

Attention may here be called to the entirely independent character of the measurements of the two observers on the same plate. The star lines measured and the comparison lines chosen as standards depend wholly upon the observer's judgment while the plate is under the microscope. The generally satisfactory accordance of the results for the same plate is evidence that the large discrepancies arising from the excessively diffuse and difficult character of some of the individual star lines are fairly well balanced in the effect on the result.

## SOURCES OF ERROR

The sources of error in this work that most naturally suggest themselves may be classified as follows: (1) those due to the spectrograph; (2) those due to the measuring instrument; (3) those due to the observer or the mode of reduction; (4) those depending upon assumed physical conditions in the stellar and terrestrial sources of light. We proceed to enumerate under these heads the points which the experience of ourselves and others, with this and other instruments, has shown to be most open to error.

1. (a) *Flexure of the spectrograph and inadequate support of the prisms.*—This serious source of error, which was in evidence with the spectrograph first used with the forty-inch refractor, was fundamentally in mind in the design and construction of the Bruce spectrograph. It was accordingly made more rigid than any previous instrument of the kind, principally with steel construction, and we have detected no evidences whatever of error in this respect during a year's use of the spectrograph.

(b) *Imperfection of prisms.*—The experience with the first set of prisms supplied for the Bruce spectrograph, which has been recounted in the article by Frots already cited, gave us special reason for caution in respect to the homogeneity of the glass of the prisms. The surfaces, by the Brashear Company, easily fulfil all the requirements, as was also true of the first set. The numerous tests in the summer of 1901 did show that there was a slight difference in the performance of the thick and thin halves of the prisms, and that the definition was slightly improved by reducing the aperture to one-half. The gain in sharpness of the lines was not sufficient, however, to justify the loss of light, and the full aperture of 51 mm. of the collimated beam has been regularly used. The effect must be a slight broadening of the lines of the stellar spectrum and of the comparison spectrum, and hence the result upon the determination of the radial velocities should be very small, increasing the accidental errors but not producing systematic ones. It is not possible to use lines as close together in stellar spectra of the solar type as could be done with perfect prisms, but the effect on such "blends" would be accidental and not systematic.

(c) *Variations in the temperature of the prisms during exposure.*—This source of error is fully suppressed by the temperature case and electric heating. Although the control is not automatic the observer has little difficulty in maintaining the temperature of the air about the prisms within a range of 0.2 C. during a winter night. In one respect our arrangements are not perfected in regard to temperature. When the dome is opened for solar observations during a considerable part of the day, the temperature in the spectrograph necessarily rises much higher than the normal value for the night, and consequently the temperature inside the glass of the prisms will be falling during the latter part of the afternoon and early evening. It would be desirable to have means for keeping the temperature of the spectrograph as low during the day as it is likely to be at night. However, as the exposures for the comparison spectrum are symmetrical with respect to the star exposure (except in the case of a few of the earlier plates), the effect of a lack of perfect uniformity in the temperature within the prisms will be to broaden the lines of the two spectra alike and to produce no systematic errors in radial velocities.

(d) *Behavior of lens of Camera B.*—The irregularly recurring astigmatism of this lens, mentioned on page 4, opens a possibility of systematic error. The effect generally is to produce a slight shading or fringe on the more refrangible side of the lines, which is more evident for the emission lines of the spark spectrum than for the absorption lines of the stellar spectrum. Hence there would be a tendency to make the settings too far toward the violet on the spark lines, which would yield too large a positive radial velocity for a stellar spectrum made when the lens was in the disturbed condition. We have always intended to use Camera A when B was thus affected, and to measure no B plates showing unsymmetrical comparison lines. If it has occurred that this condition was not noticeable though present, there may be a slight systematic effect on some of the B plates, but it does not appear on comparing the values obtained with the two cameras.

(e) *Adjustment of spark apparatus.*—The proper adjustment of the source of the comparison spectrum so that the collimator lens shall be fully and uniformly illuminated by it, is one of the most essential conditions in the use of the spectrograph. The angular apertures of the mirror first used for projecting the image of the spark upon the slit, and of the lens later substituted, were both more than twice as great as that of the collimator lens as seen from the slit. Within this latitude for maladjustment the position of the spark image (purposely somewhat out of focus) could be checked by direct observation of the polished jaws of the slit, or by the symmetry of the illumination of the double window as seen from behind the slit—both of which modes of observation are made possible by the arrangement of the guiding apparatus. On unscrewing the guiding telescope the collimator lens can be viewed directly by the light reflected from the first surface of the first prism, and the equality of its illumination tested while the spark is in action. The method of placing a photographic plate immediately over the lens has proved thoroughly satisfactory and more trustworthy than the visual method. It is not impossible that some of the early plates taken when the mirror was used may be open to danger of partial maladjustment of the spark; but if so, this should show in the control plates of Moon and stars (pp. 18 to 32), and there is no evidence of discrepancies which are not wholly within the range of the errors of observation (measurement).

2. *Errors due to the measuring instrument.*—The only source of error here of consequence lies in the screw. Optical distortions are not to be feared in the microscope, as only the center of the field is used and the recticle is fixed. It has a slight adjustment in position angle, so that the threads can be made parallel to the lines of the spectrum, even if the latter are not absolutely perpendicular to the length of the spectrum. A preliminary examination of the periodic errors of the screw showed that they were not large enough to require correction in the case of the *Orion* type stars, upon whose broad lines the errors of setting are necessarily large. They are, however, of a magnitude sufficient to affect the velocities derived from the sharp lines of solar stars. It has not been permissible, however, to delay this publication long enough to include them in our reductions, although a large part of the necessary observations have recently been made for both measuring machines.

It therefore remains to examine the probable effect of these errors upon the control plates. Measurements with machine G 2 (used by Adams) of a fixed distance on a glass scale, distributed over the part of the screw actually used, indicated a maximum departure from the mean of  $\pm 2\mu$ . If a star line were actually affected by this amount, the error in the velocity from that line would be about 2.6 km. for B plates or 3.2 km. for A plates. But the average departure would not exceed one-half of this, and in the best part of the screw it would not be over one-fourth. In the case of plates of the Moon a considerable number of the lines measured are also present in the comparison spectrum, so that the settings are made at practically the same part of the screw, and the periodic errors would be without effect. Since the plate is measured in both directions, starting at different readings of the head, the resulting error will be reduced by one-half on the average, but cannot be increased. Probably the effect on the velocity for the average line will not exceed three- or four-tenths of a kilometer, and as the mean velocity depends upon more than ten lines, it seems safe to believe that the radial velocity of the Moon or solar star from that plate will not be in error by over 0.1 km. on account of periodic errors of the screw. The progressive errors are quite negligible.

For machine G 1 (used by Frost), with which comparatively few of the control plates were measured, the maximum screw errors are somewhat less, not exceeding  $\pm 1.5\mu$ . The effect on the radial velocities measured will doubtless not exceed 0.1 km.

In these machines some changes have been made, tending to remove the slight amount of lost motion noticed earlier. The weights taking up the lost motion were somewhat increased. As all settings have uniformly been made in alternate directions there does not seem to be reason for fear of uncertainty in the measures on this account.

3. (a) *Errors due to the observer.*—Measurements of negatives under the microscope are doubtless liable to a variety of subjective errors, which should be more constant than in case of visual measurements of a similar class at the telescope. The one most familiar is that of the different habit of setting upon the dark and light lines on the negative. The process is clearly quite different in placing a dark line of the reticle, or "thread," on the center of a white line in the stellar spectrum from that in bisecting the dark comparison line with the dark "thread." The former is the easier and surer process, although the experienced observer doubtless has his habit of setting too far toward the right or toward the left, though perhaps very slightly. In the more difficult process of centering black upon black the error is greater, and probably for most observers is a function of the intensity or size of the dark line. But this personality error is largely eliminated by the regular practice of reversing the plate under the microscope and remeasuring. Measurements by Frost in 1899 upon a positive of a plate of *Polaris* yielded the same difference for violet to left—violet to right as did the measures upon the negative, but with the sign reversed. The numerical value of this difference has been quite constant and large for Frost, for B plates about 4km., in the sense that a plate measured with violet to left would require a correction of  $-2\text{km.}$  For Adams the whole amount is about 1.7km. and the sign opposite, so that a plate measured with violet to left would require a correction of about  $+1\text{km.}$

(b) *Errors due to the mode of reduction.*—It might be thought that an improvement would have been made in the reduction process by using the exponential form of Hartmann's formula. While the wave-lengths would thus have been a little more closely obtained, the gain would not have offset the increased expenditure of time. As a matter of fact, with the method used of correcting the formula at every point where a comparison line was measured (which occurred as near as possible to the position of each star line), the accuracy of the formula is of small consequence, and almost any formula could have been employed, provided only that the differences for short stretches of spectrum could be regarded as linear.

Probably it would also be regarded by some as advantageous to smooth out the accidental errors of settings on the comparison lines by a curve. We have feared the arbitrariness of curve drawing, and have ordinarily thrown the accidental errors upon the star line, although where two comparison lines have fallen close together, with no star line intervening, the mean correction has commonly been taken, valid for the mean wave-length. In a few cases of extrapolation beyond the limits of the formula there has been a slight uncertainty as to the proper correction to the "wave-length by formula" of the stellar lines, but the effect would be small.

To conform with Rowland's tables the reductions have been carried out so as to be accurate to the thousandth of the tenth-meter. This gives a specious precision to the displacement for the lines whose wave-lengths have been measured only to the hundredth. In general we should not wish to place any reliance on anything less than the whole kilometer for the best measurable of the *Orion* type stars; and in view of all the sources of error now discussed, many of them not correctable in our present state of knowledge, almost the same can be said for the stars of the solar type.

It has not been possible for us to give the time necessary for the duplicate calculation of the numerical quantities involved in our detailed reductions, so that errors doubtless occur. In general these must be small, however, as those involving an amount as large as 0.02 or 0.03 tenth-meters would be noticeable as breaking the smoothness of the run of the "corrections to comparison lines;" and all such cases have been checked. It does not seem to us likely that these errors in computation can affect the mean value of the radial velocity from any one plate by more than a very small fraction of a kilometer.

In the computation of some of the plates measured by Frost assistance was received from Miss Anne S. Young, research assistant at the observatory during the summer quarter of 1902.

#### 4. *Errors due to assumptions as to physical conditions.*

(a) In adopting the wave-lengths given in Rowland's table for the solar spectrum for our spark lines, we obviously assume that the conditions in the sun's reversing layer and in the spark are

sufficiently alike as to pressure and otherwise to justify the procedure. Determinations of the wave-lengths of the lines in the spark spectrum of titanium, of an order of accuracy equal to that of Rowland's table, are not available, and there would perhaps be quite as much assumption in using arc wave-lengths as solar wave-lengths. It is a fact that the relative intensities of the *Ti* spark lines on our plates follow much more closely the estimates in Rowland's table than they do Hasselberg's estimates for the arc spectrum of *Ti*. This indicates that the principal dark lines in the solar spectrum due to titanium are enhanced lines, and it suggests that the conditions may have some degree of similarity in sun and spark.

Jewell has found a slight systematic difference between arc and solar wave-lengths,<sup>4</sup> the metallic lines being relatively displaced toward the violet by something like 0.01 to 0.02 tenths-meters. Correction was made for this in the determination of Rowland's standards,<sup>5</sup> as its origin was then supposed to be instrumental. Jewell interprets it as an effect of the density and pressure at the level in the solar atmosphere at which the particular line is produced. The direction of the displacement would indicate a greater pressure in the solar atmosphere than in the arc. If the spark lines are also shifted toward the red relatively to the arc, the effect upon our measured radial velocities might be diminished. The large shifts of this sort described by Haschek<sup>6</sup> were not confirmed in amount by preliminary experiments made at the Yerkes Observatory by Dr. N. A. Kent, who found shifts of only about the order of those measured by Jewell. In the present state of our knowledge we therefore cannot say with any certainty how much our results are affected by the use of solar wave-lengths for our *Ti* lines; but presumably by an amount corresponding to less than 0.02 tenth-meters, or about 1.4 km., and perhaps very much less. The sign, moreover, cannot be given.

(b) The assumption that stellar wave-lengths are the same as those for the corresponding elements in the laboratory, if incorrect, also renders our measurements of velocity liable to some uncertainty, at present indeterminate. There are some instances where a distinct difference in wave-length is indicated. The most conspicuous case is that of the line always attributed to magnesium, at  $\lambda 4481$ . Laboratory determinations of this diffuse line in the spark spectrum (obtainable also in the rotating arc) give a value of about  $\lambda 4481.32$ ,<sup>7</sup> while the value obtained by Adams<sup>8</sup> from a number of plates of *Sirius*, and of  $\gamma$  *Geminorum* and  $\theta$  *Leonis*, is 4481.40. The latter value also satisfies the measurements for most of the stars included in this paper, and it has uniformly been used, as we are not prepared to adopt the radical procedure of employing a still different value for the three or four stars for which an intermediate value of this wave-length would perhaps give velocities more accordant with those from other lines. The wave-length found for this line by Scheiner<sup>9</sup> in the spectra of eighteen stars of the first type is 4481.44 (Rowland's scale).

Finally, in respect to wave-lengths, it should perhaps be mentioned that a relative error of  $\pm 0.01$  tenth-meter in Rowland's value for a line would produce an error in our velocity for that line of  $\pm 0.7$  km. Probably errors in Rowland's table as large as that are very rare, and Rowland may underestimate the accuracy of his standards in his statement "From the tests I have made on my standards, I am led to believe that down to wave-length 7000, a correction not exceeding  $\pm 0.01$  division of Ångström (1 part in 500,000), properly distributed, would reduce every part to perfect relative accuracy."<sup>10</sup>

Of course the precision of the absolute wave-lengths of Rowland's table does not affect our results.

<sup>4</sup> *Astrophysical Journal*, Vol. III (1896), pp. 89-113.

<sup>5</sup> H. A. ROWLAND, "On a Table of Standard Wave-Lengths of the Spectral Lines," *Memoirs of the American Academy of Arts and Sciences*, Vol. XII (1896), No. 2.

<sup>6</sup> *Astrophysical Journal*, Vol. XIV (1901), p. 154.

<sup>7</sup> HENRY CREW, *ibid.*, Vol. XVI (1902), p. 247.

<sup>8</sup> *Ibid.*, Vol. XV (1902), p. 216.

<sup>9</sup> *Publicationen des Astrophysikalischen Observatoriums zu Potsdam*, Bd. VII (1895), Theil II, p. 315.

<sup>10</sup> *Memoirs of the American Academy of Arts and Sciences*, Vol. XII, No. 2, p. 110.

## WAVE-LENGTHS OF THE PRINCIPAL STAR LINES USED

The tables which follow contain all of the more important star lines which we have employed, with the exception of such lines as occur in stars of the solar type of spectrum and are not blends. As the wave-lengths of the latter are taken directly from Rowland's table of solar spectrum wave-lengths, it has not seemed necessary to repeat them here. For the sake of completeness the value of a displacement of one tenth-meter in kilometers per second for the various wave-lengths given is included in the tables.

(a) *Blends*.—While we have endeavored, as far as possible, in our measures of plates of the Moon, planets, and stars of the solar type of spectrum, to use only single lines, it has been found impossible to avoid blended lines entirely, as some of the best lines in the spectra are of this nature. In such cases we have assigned weights to the component lines according to the intensities given in Rowland's table. This procedure is evidently rigorous for the Moon and planets, and proves satisfactory in the case of most of the stellar lines used in the solar stars we have investigated. Occasionally, however, a line of slight intensity in the Sun rises to considerable intensity in a star and materially changes the wave-length of a blended line. In such a case the change shows itself by the systematic deviation of this line from the other lines of a plate, and the line is rejected after a sufficient number of plates have shown the deviation to be unquestionably systematic.

The decision as to what intensity a line should have in order to exert an influence upon a closely adjacent line is naturally somewhat arbitrary, and depends upon the quality of the plate considered. In general, however, our experience shows that upon a plate of quality suitable for good measurement a line of intensity "0" on Rowland's scale has an appreciable influence, while fainter lines may be neglected. But this does not hold if the adjacent line is overpoweringly strong, as in such a case the strong line may stand out clearly against the fainter without being influenced by it. A case of this sort is the iron line  $\lambda$  4528.798 of intensity 8 in the solar spectrum, measures of which do not indicate any disturbing effect from the several faint lines near it.

The following table contains the wave-lengths of the blended lines most frequently used. For the sake of brevity, those which have been used but rarely are not included, but the wave-lengths employed in such cases, are given in column five of the detailed statement of the measurements on pp. 18 ff. and 33 f.:

Element	Wave-Length	No. of km. per tenth-meter	Element	Wave-Length	No. of km. per tenth-meter
<i>Ti; Fe</i>	4427.420	67.73	<i>Cr, Mn; Ti</i>	4501.422	66.61
<i>Fe; Ti</i>	4434.021	67.63	—	4515.475	66.40
<i>Cu; Fe</i>	4435.184	67.61	<i>Fe?; —; Ti</i>	4522.853	66.30
<i>Zr Fe; Ti?</i>	4450.597	67.37	—; <i>Fe</i>	4525.285	66.26
<i>Mg; —</i>	4456.030	67.29	—; <i>Cr; Fe</i>	4526.644	66.24
<i>Fe; Fe; Zn; Mg</i>	4455.656	67.27	<i>Ti; —</i>	4527.518	66.23
<i>Fe; Mg</i>	4460.460	67.23	<i>Ti; Co; —</i>	4534.168	66.13
<i>Ni; Fe</i>	4466.701	67.13	<i>Fe; Ti; Co</i>	4549.767	65.91
<i>Fe; Mg; Ni</i>	4472.958	67.04	<i>Cr; Co; Fe</i>	4565.750	65.68
<i>Fe; Ag</i>	4476.214	67.00	<i>Ca; Co, Fe</i>	4581.634	65.44
—, <i>Fe; Fe</i>	4482.376	66.90	<i>Cr; Fe</i>	4611.455	65.02
<i>Cr; Zr</i>	4497.046	66.68	<i>Fe; Cr, La</i>	4613.465	64.99

(b) *Oxygen and nitrogen lines*.—The wave-lengths of the following oxygen and nitrogen lines occurring in the spark spectrum of air have been determined by us on plates taken with the concave grating, with various elements serving as the spark electrodes. The values have been published in the *Astrophysical Journal*, Vol. XVI (1902), pp. 118-20. The identifications are those of Neovius.<sup>11</sup>

<sup>11</sup> *Astrophysical Journal*, Vol. XVII, 1901.

Element	Wave-Length	No. of km. per tenth-meter	Element	Wave-Length	No. of km. per tenth-meter
<i>O</i>	4317.272	69.46	<i>N</i>	4601.632	65.17
<i>O</i>	4319.762	69.41	<i>N</i>	4607.305	65.08
<i>O</i>	4345.677	69.00	<i>N</i>	4614.033	64.98
<i>NO</i>	4348.134	68.96	<i>N</i>	4621.548	64.88
<i>O</i>	4349.541	68.94	<i>N</i>	4630.703	64.75
<i>O</i>	4351.495	68.91	<i>O</i>	4638.937	64.64
<i>O</i>	4367.012	68.66	<i>O</i>	4641.886	64.60
<i>O</i>	4415.076	67.92	<i>N</i>	4643.244	64.58
<i>O</i>	4417.121	67.88	<i>O</i>	4649.250	64.49
<i>NO</i>	4447.163	67.42	<i>NO</i>	4650.925	64.47
<i>O</i>	4561.066	65.31	<i>O</i>	4661.728	64.32
<i>O</i>	4596.291	65.24			

(c) *Silicon lines*.—The following wave-lengths of the three silicon lines used by us are those given by Exner and Haschek,<sup>12</sup> who used the spark passing between electrodes of metallic silicon as the source of spectrum. The occurrence of these lines in the spectra of stars resembling  $\beta$  *Crucis* was observed by McClean and by Gill, and their origin was traced by Lunt in a careful series of experiments at the Cape Observatory. It is unfortunate that the wave-lengths, particularly that of the third line, cannot be more accurately assigned. This is doubtless due to their diffuse character in the spark spectrum, which was remarked by Exner and Haschek.

Wave-Length	No. of km. per tenth-meter
4552.75	65.87
4567.95	65.64
4574.9	65.54

(d) *Magnesium lines*.—The magnesium line at  $\lambda 4352$  occurs in the Sun, and accordingly its wave-length is given by Rowland. The wave-length of the line at  $\lambda 4481$  has been determined by Adams from measures of the spectra of stars of Vogel's type Ia,<sup>13</sup> and is discussed more fully on p. 13.

Wave-Length	No. of km. per tenth-meter
4352.083	68.90
4481.400	66.91

(e) *Helium lines*.—The wave-lengths of the helium lines which we have used are those given by Runge and Paschen.<sup>14</sup> The double lines at  $\lambda 4471$  and  $\lambda 4713$  have been blended, the weights assigned to the components being 6 and 1 for  $\lambda 4471$ , and 3 and 1 for  $\lambda 4713$ . (The intensities given by Runge and Paschen are respectively 6 and  $<1$  and 3 and  $<1$ .)

Wave-Length	No. of km. per tenth-meter
4388.100	68.33
4437.718	67.57
4471.676	67.06
4713.308	63.62

<sup>12</sup>"Note on the Spectrum of Silicon," *Astrophysical Journal*, Vol. XII (1900), pp. 48, 49.

<sup>13</sup>"On the Spectrum of Clèveite Gas," *ibid.*, Vol. III (1896), pp. 1-28.

<sup>14</sup>"Some Results with the Bruce Spectrograph," *ibid.*, Vol. XV (1902), pp. 214-17.



Object	Service Number	Date	Middle of Exposure	Duration	Hour Angle at End	Altitude	Comparison Beginning	End	Self-Induction	Temperature Beginning	End	Seeing	Obs. Serv.	Remarks
$\beta$ Orionis...	B213	Nov. 7	12 06	9	h. m.	mm.			turns					
$\gamma$ Orionis...	B215	Nov. 7	15 00	35	E 1 45	0.038	T 7	T 7	50	3.3	3.0	3.3	2.8	Excellent
$\delta$ Orionis...	B218	Nov. 8	14 06	9	E 1 15	0.038	T 7	T 7	"	3.0	2.9	3.0	3.0	Excellent
$\epsilon$ Orionis...	B220	"	14 39	25	W 0 15	0.038	T 7	T 7	"	4.9	5.2	5.1	5.2	Good; hazy
$\zeta$ Orionis...	B221	"	h. m.	m.	W 0 45	0.038	T 7	T 7	"	5.1+	5.4	5.1	4.9	Fair
$\eta$ Orionis...	B224	Nov. 13	13 50	28	E 1 25	0.038	T 14	T 14	"	8.5	8.5	8.5	8.2	Fair
$\theta$ Orionis...	B228	"	13 50	28	E 0 15	0.038	T 14	T 14	"	7.6	6.6	7.7	7.0	Poor
$\iota$ Orionis...	B231	Nov. 14	13 19	9	E 0 10	0.038	T 12	T 12	"	9.0	9.0	9.0+	9.2	Good
$\kappa$ Orionis...	B232	"	14 04	62	W 2 48	0.038	T 7	T 7	"	9.0	9.2	9.0	8.8	Fair
$\lambda$ Orionis...	B233	Nov. 15	12 52	9	E 0 30	0.038	T 11	T 11	"	-1.1	-1.1	-1.1	-1.2	Good
$\mu$ Orionis...	B237	"	12 52	9	E 0 30	0.038	T 11	T 11	"	-0.2	0.0	-0.4	-0.7	Good
$\nu$ Orionis...	B246	Nov. 27	6 11	83	E 0 45	0.025	T 11	T 11	"	0.8	1.0	0.8	0.4	Good to fair
$\xi$ Orionis...	B248	"	10 48	112	W 3 45	0.025	T 4	T 6	"	0.9	0.9	0.9	0.3	Good
$\zeta$ Orionis...	B252	"	15 22	14	W 2 50	0.025	T 6	T 6	"	0.9	0.4	0.9	0.5	Good
Moon.....	B254	Dec. 18	7 36	27	"	0.025	T 15	T 15	"	-15.7	-15.7	-15.6+	-15.8	4; 3
$\beta$ Orionis...	B257	"	12 12	8	W 1 00	0.038	T 15	T 15	"	-15.8	-15.6	"	"	4; 2
$\beta$ Orionis...	A267	Dec. 19	11 34	13	W 0 30	0.038	T 7	T 7	"	-13.6	-13.0	1-3; 2	"	4; 1
$\beta$ Orionis...	B261	Dec. 31	6 12	8	E 1 10	0.025	T 12	T 12	"	-2.0	-2.3	"	"	4; 4
$\gamma$ Orionis...	B262	"	9 39	25	E 0 45	0.025	T 10	T 10	"	-1.9+	-1.6	-2.0	-2.2	4; 4
$\beta$ Orionis...	A300	Jan. 4	11 44	10	W 1 40	0.025	T 9	T 9	"	-6.6	-6.4	"	"	4; 2
$\alpha$ Orionis...	A303	Jan. 8	12 17	17	W 2 28	0.025	T 12	T 12	"	-13.3	-13.3	"	"	4; 2
$\beta$ Orionis...	A306	"	12 15	8	W 2 28	0.025	T 9	T 9	"	3.6	3.6	"	"	4; 1
$\beta$ Orionis...	B270	Jan. 9	8 41	8	E 1 10	0.025	T 11	T 11	"	3.2	3.2	"	"	4; 4
$\alpha$ Tauri...	B275	Jan. 16	8 15	25	E 0 20	0.029	T 27	T 27	350	-3.3	-3.2	-3.4	-3.6	4; 4
$\alpha$ Orionis...	B277	"	11 02	8	W 1 50	0.038	T 22	T 22	"	-3.8	-3.9	"	"	4; 4
$\alpha$ Orionis...	B282	Jan. 24	6 50	10	E 1 55	0.025	T 20	T 20	"	-3.8	-3.9	"	"	4; 4
$\zeta$ Draconis...	B290	Feb. 3	16 24	83	E 0 00	0.040	T 9 at 16:07	T 6	"	-13.7	-13.4	-13.7	-13.3	4; 4
$\beta$ Orionis...	A312	Feb. 10	8 54	10	W 1 15	0.020	T 30	T 30	"	-7.6	-7.4	"	"	4; 4
$\alpha$ Orionis...	A314	"	16 12	14	W 2 50	0.040	T 7	T 7	"	-7.6	-7.4	"	"	4; 4
Moon.....	A320	Feb. 19	7 20	37	E 2 20	0.033	T 11	T 12	"	-5.3	-5.0	-5.3	-5.1	4; 4
$\zeta$ Draconis...	A324	"	14 33	42	E 1 10	0.045	T 7 at 14:26	T 6 at 14:45	"	-5.2	-5.0	-5.2	-5.5	4; 4
$\gamma$ Herculis...	A325	"	15 33	55	E 2 05	0.050	T 5	T 5	"	-5.2	-5.6	-5.2	-5.4	4; 4
$\alpha$ Orionis...	A330	Mar. 3	7 44	14	W 1 50	0.025	T 15	T 15	"	-5.2	-5.6	"	"	4; 4
$\alpha$ Bootis...	B298	Mar. 12	12 13	16	E 2 20	0.020	T 35	T 35	"	3.5	3.5	"	"	4; 3
$\gamma$ Herculis...	B295	"	16 09	17	E 0 20	0.045	T 12	T 12	"	3.5	3.4	3.5	3.3	4; 4
$\alpha$ Orionis...	B295	Mar. 13	8 29	30	W 2 30	0.040	T 10	T 11	"	9.3	9.3	"	"	4; 2
$\alpha$ Orionis...	B298	"	9 11	57	W 3 05	0.040	T 10	T 10	"	9.3	9.3	"	"	3; 1
$\gamma$ Orionis...	B299	"	9 53	30	W 4 15	0.040	T 11	T 11	"	9.3	9.4	"	"	3; 1
$\alpha$ Bootis...	B300	"	11 29	24	E 3 00	0.020	T 10	T 10	"	9.3	9.8	"	"	4; 2
$\gamma$ Herculis...	B301	"	13 36	80	E 2 30	0.040	T 10	T 10	"	9.3	9.9	9.3	9.0	4; 2
$\alpha$ Bootis...	B304	Mar. 26	12 50	55	W 3 10	0.040	T 10	T 12	"	8.7	8.6	8.7	8.6	3; 2
Moon.....	A337	"	14 49	35	W 0 45	0.025	T 8	T 8	"	8.6+	8.6+	"	"	3; 2
$\alpha$ Bootis...	B304	Apr. 2	9 51	22	E 3 20	0.020	T 10	T 10	"	2.0	2.3	2.0	1.8	4; 4
$\gamma$ Corvi...	B305	"	10 32	39	E 0 20	0.040	T 3	T 3	"	2.0	2.3	"	"	4; 4
$\alpha$ Orionis...	B307	Apr. 3	10 57	58	W 3 25	0.020	T 3	T 3	"	8.8	8.5	"	"	4; 4
$\gamma$ Corvi...	B312	"	10 32	30	E 3 30	0.040	T 3	T 4	"	4.8	4.6	4.9	5.2	4; 4
$\gamma$ Herculis...	B313	"	11 29	55	E 3 30	0.040	T 4	T 3	"	4.8	4.8	4.8	5.0	4; 4
$\alpha$ Orionis...	B315	Apr. 9	7 47	28	W 3 35	0.038	T 3	T 3	"	8.0	8.5	8.1	8.5	4; 4
$\alpha$ Orionis...	B316	"	8 21	33	W 4 20	0.038	T 7	T 7	"	"	"	8.3	8.5	4; 4
$\gamma$ Orionis...	B317	"	9 04	27	W 5 10	0.038	T 7	T 7	"	"	"	8.4	8.6	2; 3
Moon.....	B323	Apr. 16	11 12	35	W 3 50	0.028	T 6	T 9	"	7.4	7.4	"	"	3; 4
$\gamma$ Corvi...	B324	"	12 15	55	W 2 05	0.040	T 8	T 8	"	7.4	7.4	"	"	3; 4
$\alpha$ Orionis...	B328	Apr. 19	8 40	39	E 1 00	0.028	T 4	T 6	"	7.8	7.8	7.8	7.6	3; 2
$\gamma$ Leonis...	B329	"	9 43	61	W 2 10	0.040	T 3	T 3	"	7.8	7.3	7.8	7.5	3; 2
$\gamma$ Corvi...	B330	"	11 03	69	W 1 15	0.040	T 3	T 3	"	7.8	7.3	7.8	7.5	3; 2
$\gamma$ Leonis...	B333	Apr. 23	9 31	65	W 2 10	0.040	T 3	T 3	"	11.5	14.6	14.5	14.4	1; 1
$\alpha$ Orionis...	B335	Apr. 30	9 53	85	W 3 10	0.038	T 10	T 10	"	15.7	14.8	15.7	15.7	3; 2
$\alpha$ Bootis...	B342	May 7	11 17	26	W 0 30	0.023	T 4	T 3	150	11.3	11.9	11.3	10.8	2; 1
$\zeta$ Ophiuchi...	B347	May 14	13 14	114	E 0 10	0.038	T 2	T 2	"	20.4	20.6	20.5	20.4	3; 4
$\zeta$ Draconis...	B357	May 30	10 04	44	E 2 05	0.040	T 3	T 3	"	16.2	16.0	16.2	16.2	3; 1
Moon.....	B363	June 29	12 55	39	W 1 05	0.039	T 3	T 1	350	17.6	18.5	17.8	17.8	2; 2
$\zeta$ Ophiuchi...	B369	June 25	13 41	78	W 2 50	0.040	T 2	T 1	"	16.4	16.4	"	"	2; 2
$\alpha$ Bootis...	B371	June 26	9 30	12	W 1 40	0.025	T 2	T 4	"	28.6	29.4	28.5	28.0	4; 4
$\zeta$ Ophiuchi...	A346	July 7	11 32	81	W 1 25	0.035	T 6	T 5	"	22.8	22.7	22.8	22.5	3; 1
$\alpha$ Bootis...	A349	July 11	11 55	102	E 0 20	0.033	T 5	T 5	"	23.4	23.9	23.6	24.2	2; 2
$\alpha$ Delphini...	A353	"	12 48	120	W 1 05	0.040	T 3	T 4	"	24.4	24.7	24.5	24.5	2; 3
$\alpha$ Delphini...	A355	July 22	13 10	100	E 2 30	0.038	T 33	T 25	"	20.3	19.8	"	"	2; 3
$\alpha$ Delphini...	A358	July 23	11 53	59	E 3 05	0.040	T 18	T 25	"	22.7	22.6	22.7	22.6	2; 3
$\alpha$ Delphini...	A359	"	13 50	93	W 2 25	0.040	T 20	T 30	"	22.7	22.6	22.7	22.8	2; 4
$\alpha$ Delphini...	A363	July 31	10 45	110	E 0 10	0.040	T 40	T 45	"	25.5	25.5	25.4+	25.2	3; 1
$\gamma$ Lyrae...	A365	"	14 51	102	W 2 20	0.038	T 33	T 30	"	17.8	17.8	17.8	17.8	4; 4
$\alpha$ Orionis...	B385	Aug. 11	10 10	40	W 2 20	0.038	T 25	T 25	"	19.6	18.9	"	"	3; 3
$\gamma$ Pegasi...	B385	Aug. 22	14 40	71	W 1 15	0.033	T 30, Cr 50	T 35, Cr 100	"	22.2	22.2	22.2	22.0	3; 3
$\gamma$ Pegasi...	B397	Aug. 27	9 00	120	W 2 28	0.040	T 60	T 50	"	22.2	22.0	22.2	22.0	3; 3
$\zeta$ Orionis...	B398	"	12 47	37	E 1 30	0.038	T 45	T 45	"	22.2	22.0	22.2	22.0	3; 3
Moon.....	B401	"	12 47	37	E 1 30	0.038	T 45	T 45	"	16.8	16.9	16.8	16.4	4; 1
$\gamma$ Orionis...	B402	Sept. 3	9 00	150	W 3 15	0.043	T 60	T 60	"	16.8	16.9	16.8	16.3	4; 1
$\alpha$ Herculis...	B403	"	11 20	55	W 5 20	0.043	T 60	T 50	"	20.3	20.2	"	"	3; 0
$\alpha$ Bootis...	A373	Sept. 6	7 43	57	E 1 30	0.038	T 45	T 40	"	19.4	19.6	19.6	19.7	4; 2
$\gamma$ Lyrae...	A379	Sept. 7	10 20	120	W 3 05	0.038	T 45	T 40	"	12.7	12.7	12.7	13.2	3; 1
Moon.....	B408	Sept. 13	10 13	35	W 1 32	0.038	T 40	T 40	"	12.7	13.0	12.7	13.2	2; 3
$\gamma$ Lyrae...	B409	"	11 57	150	W 5 35	0.043	T 40	T 40	"	15.4	15.4	15.4	15.2	3; 3
$\gamma$ Pegasi...	B419	Oct. 9	11 53	120	W 5 35	0.043	T 40	T 40	"	15.4	15.4	15.4	15.2	3; 3
$\alpha$ Orionis...	B422	Oct. 15	14 12	120	W 3 45	0.040	T 20	T 20	"	15.4	15.4	15.4	15.2	3; 3
Moon.....	B423	"	15 44	30	E 1 01	0.028	T 30	T 40	"	15.4	15.4	15.4	15.3	3; 1
$\zeta$ Persei...	B424	"	16 43	60	E 2 55	0.038	T 25	T 25	"	15.4	15.4	15.4	15.4	3; 1
$\alpha$ Orionis...	B427	Oct. 16	9 32	125	W 5 10	0.043	T 40	T 40	"	10.1	9.8	10.1	10.0	2; 3
$\gamma$ Orionis...	B433	Oct. 29	19 04	25+	E 1 52	0.038	T 25	T 35	"	7.6	7.8	7.7	7.9	2; 0
$\zeta$ Orionis...	B434	"	19 45	24	E 1 12	0.038	T 30	T 35	"	7.7	7.9	"	"	3; 2
$\alpha$ Orionis...	B441	Oct. 30	21 19	16	W 0 27	0.038	Cr 30	T 60	"	12.7	12.5	7.1	6.9	3; 1
$\alpha$ Orionis...	B444	Nov. 6	13 38	49	W 2 51	0.043	T 30	T 50	"	7.2	7.4	"	"	4; 5
$\alpha$ Can. Maj.	B451	"	21 47	30	W 0 00	0.033	T 30	T 30	"	9.8	9.4	9.7	10.1	3; 1
$\alpha$ Can. Maj.														

## DETAILED MEASURES AND REDUCTIONS

## CONTROL PLATES OF THE MOON, VENUS, AND SOLAR STARS

The following section contains the results of measures upon plates of the Moon, Venus, and certain stars with known velocities taken for the purpose of guarding against instrumental errors. The series covers practically the entire interval within which the measures given in the present paper occur, and no evidence is shown of the existence of errors of this nature. The measured velocity in the case of the Moon and Venus is compared with the computed velocity, and in the case of stars with the results of other observers for the same stars. Professor Campbell's convenient formulæ were used in the derivation of the theoretical velocity of the Moon and Venus.

The detailed measurements on the different plates follow. The plates of the Moon and Venus are grouped together and arranged in chronological order, while the separate stars are given in order of right ascension. The Greenwich mean time and hour angle given for each plate refer to the middle of the exposure. Following this is the name of the person who measured the plate, the magnifying power employed, and a brief statement as to the quality of the plate. Unless otherwise specified the comparator used by Frost was G 1, by Adams G 2.

The first column of the tables contains the means of the settings upon the individual lines. S denotes a line in the spectrum of the star, Moon, or planet, while a comparison line is indicated by the symbol of the element to which it is due.

In all cases where the curvature correction is given as a fraction of a millimeter at the foot of the tables, the readings upon the comparison lines given in the first column include this correction. In a few cases the correction for curvature is applied in kilometers to the end result.

The symbols  $V_a$  and  $V_d$  are employed in the reduction of a star's velocity to the Sun,  $V_a$  denoting the correction due to the velocity of the Earth in its orbit, and  $V_d$  the correction due to the Earth's diurnal rotation. The total reduction to the Sun is, therefore,  $V_a + V_d$ . The corrections for the orbital velocity of the Earth have been made with the use of Schlesinger's tables of star constants (*Astrophysical Journal*, Vol. X (1899), pp. 1-13), and the diurnal corrections are taken from a table constructed for the latitude of the Yerkes Observatory.

## MOON—A 246

1901, September 26, G. M. T. 14<sup>h</sup> 48<sup>m</sup>

Measured by F.

Hour angle E 1° 56'

Poor plate

Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	Å.	mm.	mm.	Å.	mm.	km.
Ti 32 6540	Standard	+0.000	...	4427.266	...	...
S 32 1043	4427.302	...	0.000	4427.420	-0.028	-1.9
Ti 32 6522	4434.150	+0.018	...	4434.168	...	...
S 32 7896	4435.772	...	+0.029	4435.851	-0.059	-4.0
Ti 33 1646	4440.405	+0.020	...	4440.515	...	...
S 33 6242	4442.447	...	+0.015	4442.510	-0.048	-3.2
S 33 4444	4443.949	...	+0.011	4443.976	-0.016	-1.1
S 33 7363	4445.883	...	+0.002	4445.892	-0.007	-0.5
Ti 34 8589	4449.315	-0.002	...	4449.313	...	...
Ti 34 3556	4455.476	+0.009	...	4455.485	...	...
S 34 4012	4456.056	...	+0.010	4456.060	+0.006	+2.4
Ti 34 5215	4457.598	+0.012	...	4457.600	...	...
S 34 5254	4457.638	...	+0.012	4457.656	-0.006	-0.4
S 35 0044	4476.183	...	-0.023	4476.214	-0.044	-3.0
Ti 35 9625	4476.298	-0.023	...	4476.185	...	...
Ti 36 2946	Standard	0.000	...	4481.438	...	...
S 36 4373	4482.375	...	-0.001	4482.376	-0.002	-0.1
S 37 3578	4494.715	...	-0.013	4494.738	-0.006	-2.4
Ti 37 3946	4494.751	-0.013	...	4494.738	...	...
Ti 37 4770	4496.318	-0.000	...	4496.318	...	...
Ti 38 6054	4512.915	-0.000	...	4512.906	...	...

MOON A 246 *Continued*

Mean of Velocity	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
Ti 39.4200	4522.968	+0.006	.....	4522.974	.....	.....
S 39.5836	4525.257	.....	+0.014	4525.285	-0.014	-0.9
Fe 39.8337	4528.771	+0.027	.....	4528.798	.....	.....
S 39.8962	4528.806	.....	+0.027	4528.798	+0.035	+2.3
S 41.6063	4554.157	.....	±0.000	4554.211	-0.054	-3.6
Ti 41.7092	Standard	±0.000	.....	4555.662	.....	.....

Curvature Cor. +0.0002 mm.

Mean 1.2 km.

Computed Velocity -0.5

## MOON—A 253

1901, September 27, G. M. T. 16<sup>h</sup> 22<sup>m</sup>

Measured by A.

Hour angle E 1<sup>h</sup> 15<sup>m</sup>

Moon fair; comparison fair.

Power 28

Ti 26.2727	Standard	+0.000	.....	4399.935	.....	.....
S 26.9485	4407.871	.....	-0.002	4407.851	+0.018	+1.2
S 27.0037	4408.524	.....	-0.002	4408.549	-0.027	-1.8
Fe 27.5735	4415.297	-0.004	.....	4415.293	.....	.....
S 28.4366	4425.615	.....	-0.004	4425.608	+0.003	+0.2
Ti 28.5669	4427.270	0.004	.....	4427.266	.....	.....
S 28.5774	4427.398	.....	-0.004	4427.420	-0.026	-1.8
S 29.2661	4435.827	.....	-0.002	4435.851	-0.026	-1.8
S 29.8072	4442.524	.....	+0.000	4442.510	+0.014	+0.9
Ti 29.9238	4443.976	±0.000	.....	4443.976	.....	.....
S 30.2354	4447.871	.....	-0.000	4447.892	-0.021	-1.4
Ti 30.3503	Standard	±0.000	.....	4449.313	.....	.....
Ti 30.8405	4455.498	-0.013	.....	4455.485	.....	.....
S 30.8828	4456.038	.....	-0.013	4456.030	-0.005	-0.3
Ti 31.6612	4465.980	-0.005	.....	4465.975	.....	.....
S 32.4522	4476.234	.....	-0.004	4476.214	+0.016	+1.1
Ti 32.8494	4481.441	-0.003	.....	4481.438	.....	.....
S 32.9185	4482.351	.....	-0.003	4482.376	-0.018	-1.2
S 33.8508	4494.741	.....	+0.000	4494.738	+0.003	+0.2
Ti 33.9683	Standard	+0.000	.....	4496.318	.....	.....
S 34.0221	4497.041	.....	-0.001	4497.046	-0.006	-0.4
S 34.3461	4501.413	.....	-0.006	4501.422	-0.015	-1.0
Ti 34.3489	4501.451	-0.006	.....	4501.445	.....	.....

Curvature Cor. +0.0001 mm.

Mean -0.5 km.

Computed Velocity -0.6

## VENUS—B 224

1901, November 13, G. M. T. 11<sup>h</sup> 34<sup>m</sup>

Measured by A.

Hour angle W 2<sup>h</sup> 36<sup>m</sup>

Planet strong; comparison good.

Power 21

S 22.8566	4443.810	.....	+0.018	4443.976	-0.148	-10.0
Ti 22.8725	4443.958	+0.018	.....	4443.976	.....	.....
S 23.2737	4447.696	.....	+0.005	4447.892	-0.191	12.9
Ti 23.4465	Standard	±0.000	.....	4449.313	.....	.....
S 24.3103	4457.450	.....	±0.000	4457.656	-0.206	13.9
Ti 24.3261	4457.600	±0.000	.....	4457.600	.....	.....
S 25.2597	4466.505	.....	-0.005	4466.701	-0.201	13.5
S 25.4657	4468.486	.....	-0.006	4468.663	-0.183	12.3
Ti 25.4848	4468.609	-0.006	.....	4468.663	.....	.....
S 25.9135	4472.810	.....	-0.006	4472.958	-0.154	10.3
S 26.2453	4476.031	.....	-0.006	4476.214	-0.189	12.7
Ti 26.7995	4481.444	-0.006	.....	4481.438	.....	.....
S 26.8762	4482.196	.....	-0.005	4482.376	-0.185	12.4
S 28.1202	4494.513	.....	+0.008	4494.738	-0.217	14.5

## VENUS B-224—Continued

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Planet Lines	Wave-Length in Sun	Displacement	Velocity
sun.	Å. m.	t. m.	t. m.	t. m.	t. m.	km.
S 28 7897	4501.230	.....	+0.015	4501.422	-0.177	-11.8
Ti 28 8005	4501.430	+0.015	.....	4501.445	.....	.....
Ti 29 9391	4512.911	-0.005	.....	4512.906	.....	.....
S 30 1705	4515.285	.....	-0.007	4515.475	-0.197	13.1
Ti 30 4542	4518.207	-0.009	.....	4518.198	.....	.....
S 30 8831	4522.647	.....	+0.008	4522.853	-0.198	13.1
Ti 30 9178	4522.966	+0.008	.....	4522.974	.....	.....
Ti 31 3480	Standard	±0.000	.....	4527.490	.....	.....
S 31 4548	4528.607	.....	+0.000	4528.798	-0.191	12.6
S 32 9099	4544.641	.....	+0.009	4544.845	-0.195	12.9
Ti 32 9899	4544.855	+0.009	.....	4544.864	.....	.....
Ti 33 7114	4552.616	+0.016	.....	4552.632	.....	.....
S 33 8378	4553.981	.....	+0.009	4554.211	-0.218	14.4
Ti 33 9925	4555.662	+0.000	.....	4555.662	.....	.....
S 34 7298	4563.678	.....	+0.040	4563.939	-0.221	14.5
Ti 34 7439	4563.899	+0.040	.....	4563.939	.....	.....
Ti 35 4926	4572.130	+0.026	.....	4572.156	.....	.....
S 36 3248	4581.424	.....	+0.017	4581.634	-0.193	12.6
S 37 0751	4589.901	.....	+0.009	4590.126	-0.216	14.1
Ti 37 0941	4590.117	+0.009	.....	4590.126	.....	.....
S 38 9256	4611.221	.....	+0.002	4611.455	-0.232	15.1
Ti 39 4569	Standard	±0.000	.....	4617.452	.....	.....

Curvature Cor. +0.0009 mm.

Mean -13.0 km.

Computed Velocity -12.8

## MOON B 254

1901, December 18, G. M. T. 13<sup>h</sup> 36<sup>m</sup>

Hour angle W 1° 32'

Moon good; comparison rather strong.

Measured by A.

Power 21

S 23 1081	4442.519	.....	+0.028	4442.510	+0.037	+2.5
Ti 23 5599	4443.948	+0.028	.....	4443.976	.....	.....
S 23 5648	4443.994	.....	+0.028	4443.976	+0.046	+3.1
S 23 5804	4447.929	.....	+0.007	4447.892	+0.044	+3.0
Ti 24 1269	Standard	+0.000	.....	4449.313	.....	.....
S 25 0946	4468.735	.....	+0.008	4468.701	+0.042	+2.8
Ti 26 1311	4468.654	+0.009	.....	4468.663	.....	.....
S 26 1334	4468.676	.....	+0.009	4468.663	+0.022	+1.5
S 26 8995	4476.209	.....	-0.010	4476.214	-0.015	-1.0
Ti 27 4289	4481.461	-0.023	.....	4481.438	.....	.....
S 27 5242	4482.410	.....	-0.023	4482.376	+0.011	+0.7
S 28 7507	4491.745	.....	-0.029	4494.738	-0.022	-1.5
Ti 28 9085	4496.348	+0.029	.....	4496.318	.....	.....
S 29 4085	4501.450	.....	-0.022	4501.422	+0.006	+0.4
S 29 0898	4508.450	.....	-0.012	4508.455	-0.008	-0.5
Ti 30 5192	4512.911	+0.005	.....	4512.906	.....	.....
S 31 0260	4525.245	.....	-0.001	4525.285	-0.041	-2.7
Ti 31 9069	Standard	+0.000	.....	4527.490	.....	.....
S 32 0328	4528.838	.....	+0.002	4528.798	+0.042	+2.8
Ti 32 2333	4552.595	+0.037	.....	4552.632	.....	.....
S 33 3791	4554.197	.....	+0.032	4554.211	+0.018	+1.2
Ti 33 2587	4563.935	+0.004	.....	4563.939	.....	.....
S 33 2584	4563.931	.....	+0.004	4563.939	-0.004	-0.3
S 35 9126	4571.256	.....	-0.012	4571.275	-0.007	-0.5
S 36 8271	4581.615	.....	+0.026	4581.634	+0.007	+0.5
S 37 0750	4584.013	.....	+0.027	4584.018	+0.022	+1.4
Ti 37 5932	4590.092	+0.034	.....	4590.126	.....	.....
S 38 3891	4611.405	.....	+0.008	4611.455	-0.042	-2.7
S 39 5611	4613.447	.....	+0.005	4613.465	-0.013	-0.8
Ti 39 8972	Standard	+0.000	.....	4617.452	.....	.....

Curvature Cor. +0.0007 mm.

Mean +0.5 km.

Computed Velocity +0.9

## VENUS—A 303

1902, January 8, G. M. T. 11<sup>h</sup> 28<sup>m</sup>  
Hour angle W 2<sup>h</sup> 35<sup>m</sup>

Planet strong; comparison good.

Measured by A.  
Power 28

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Planet Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
S 19.3514	4282.435	.....	+0.000	4282.565	-0.130	-9.1
Ti 19.3948	Standard	+0.000	.....	4282.860	.....	.....
S 19.4101	4283.010	.....	±0.000	4283.169	-0.159	11.1
Ti 19.7313	4286.165	+0.003	.....	4286.168	.....	.....
Ti 19.8736	4287.569	-0.003	.....	4287.566	.....	.....
S 20.0575	4289.387	.....	-0.003	4289.525	-0.141	9.9
S 20.4322	4293.110	.....	-0.004	4293.241	-0.135	9.4
S 20.5327	4294.113	.....	-0.004	4294.278	-0.169	11.8
S 21.3067	4301.892	.....	-0.006	4302.039	-0.153	10.7
Ti 21.3264	4302.091	-0.006	.....	4302.085	.....	.....
Ti 21.7183	4306.071	+0.007	.....	4306.078	.....	.....
S 21.7862	4306.763	.....	+0.006	4306.912	-0.143	10.0
Ti 22.3978	Standard	+0.000	.....	4313.034	.....	.....
S 22.5919	4315.038	.....	-0.001	4315.209	-0.172	12.0
S 22.9415	4318.664	.....	-0.001	4318.817	-0.154	10.7
Ti 23.1771	4321.121	-0.002	.....	4321.119	.....	.....
Ti 24.6852	4337.064	.....	+0.001	4337.216	-0.151	10.4
Ti 24.7781	4338.083	+0.001	.....	4338.084	.....	.....
S 24.9697	4340.468	.....	+0.002	4340.634	-0.164	11.3
Ti 25.3675	4944.448	+0.003	.....	4944.451	.....	.....
S 26.0460	4351.858	.....	+0.002	4352.007	-0.147	10.1
Ti 27.1522	4364.132	.....	±0.000	4364.274	-0.142	9.8
Ti 27.4820	Standard	±0.000	.....	4367.839	.....	.....

Curvature Cor. +0.0005 mm.

Mean -10.5 km.

Computed Velocity -11.3

## MOON—A 320

1902, February 19, G. M. T. 13<sup>h</sup> 20<sup>m</sup>  
Hour angle E 2<sup>h</sup> 38<sup>m</sup>

Moon strong; comparison good.

Measured by A.  
Power 21

S 31.3732	4399.921	.....	+0.000	4399.903	+0.018	+1.2
Ti 31.3744	Standard	+0.000	.....	4399.935	.....	.....
S 32.0370	4407.849	.....	+0.003	4407.851	+0.001	+0.1
Ti 33.6288	4427.257	+0.009	.....	4427.266	.....	.....
S 34.1240	4433.410	.....	+0.012	4433.390	+0.032	+2.2
Ti 34.1836	4434.155	+0.013	.....	4434.168	.....	.....
S 34.3183	4435.840	.....	+0.011	4435.851	±0.000	±0.0
S 34.8483	4442.514	.....	+0.005	4442.510	+0.009	+0.6
Ti 34.9634	4443.972	+0.004	.....	4443.976	.....	.....
S 34.9637	4443.975	.....	+0.004	4443.976	+0.003	+0.2
S 35.2711	4447.884	.....	+0.001	4447.892	-0.007	-0.5
Ti 35.3830	Standard	+0.000	.....	4449.313	.....	.....
Ti 36.0271	4457.594	+0.006	.....	4457.600	.....	.....
S 36.2492	4460.473	.....	+0.007	4460.480	+0.020	+1.3
Ti 36.8753	4468.654	+0.009	.....	4468.663	.....	.....
S 36.8769	4468.675	.....	+0.009	4468.663	+0.021	+1.4
S 36.9399	4469.504	.....	+0.009	4469.511	+0.002	+0.1
S 37.4477	4476.219	.....	+0.015	4476.214	+0.020	+1.3
Ti 37.8376	4481.420	+0.018	.....	4481.438	.....	.....
S 37.9107	4482.309	.....	+0.016	4482.376	+0.039	+2.6
S 38.8237	4494.747	.....	+0.002	4494.738	+0.011	+0.7
Ti 38.9387	Standard	+0.000	.....	4496.318	.....	.....
S 38.9949	4497.087	.....	±0.000	4497.046	+0.041	+2.7
S 39.3121	4501.443	.....	+0.007	4501.422	+0.028	+1.9
Ti 39.3118	4501.438	+0.007	.....	4501.445	.....	.....

Curvature Cor. +0.0005 mm.

Mean +1.1 km.

Computed Velocity +0.7

## MOON - A 337

1902, March 26, G. M. T. 20<sup>h</sup> 49<sup>m</sup>  
Hour angle: W 0° 28'

Moon fair; comparison rather strong.

Measured by A.  
Power 20

Mean of Settings	Wave-Length, in Vacuum	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
		t. m.	t. m.	t. m.	t. m.	km.
S 29.3921	4425.611	.....	±0.000	4425.608	+0.003	+0.2
Ti 29.5265	Standard	±0.000	.....	4427.266	.....	.....
S 29.5386	4427.415	.....	±0.000	4427.420	-0.005	-0.3
S 30.1644	4435.174	.....	-0.002	4435.184	-0.012	-0.8
S 30.7503	4442.519	.....	-0.005	4442.510	-0.004	+0.3
Ti 30.8661	4443.981	-0.005	.....	4443.976	.....	.....
S 30.8668	4443.989	.....	-0.005	4443.976	+0.008	+0.5
S 31.1765	4447.913	.....	-0.014	4447.892	+0.007	+0.5
Ti 31.2881	4449.331	-0.018	.....	4449.313	.....	.....
S 32.0361	4466.708	.....	-0.017	4466.701	-0.010	-0.7
S 32.7890	4468.663	.....	-0.017	4468.663	-0.017	-1.1
Ti 32.7873	4468.680	-0.017	.....	4468.663	.....	.....
S 33.3697	4476.225	.....	-0.012	4476.214	-0.001	-0.1
S 33.8257	4482.403	.....	-0.008	4482.376	+0.019	+1.3
S 34.7118	4494.760	.....	-0.001	4494.738	+0.021	+1.4
Ti 34.8584	Standard	±0.000	.....	4496.318	.....	.....
S 35.2344	4501.439	.....	±0.001	4501.422	-0.016	+1.1
Ti 35.2339	4501.446	-0.001	.....	4501.445	.....	.....
Ti 36.0651	4512.928	-0.022	.....	4512.906	.....	.....
S 36.2473	4515.470	.....	-0.012	4515.475	-0.017	-1.1
S 36.7711	4522.826	.....	+0.018	4522.853	-0.009	-0.6
Ti 36.7803	4522.856	+0.018	.....	4522.974	.....	.....
Ti 37.0698	4527.481	+0.009	.....	4527.490	.....	.....
S 37.1925	4528.799	.....	±0.000	4528.798	+0.010	+0.7
Ti 38.8393	4552.617	+0.015	.....	4552.632	.....	.....
Ti 39.6638	Standard	±0.000	.....	4563.939	.....	.....
S 39.6048	4563.954	.....	±0.000	4563.939	+0.015	+1.0

Curvature Cor. +0.0005 mm.

Mean +0.1 km.  
Computed Velocity +0.1

## MOON - B 328

1902, April 19, G. M. T. 14<sup>h</sup> 40<sup>m</sup>  
Hour angle: E 1° 15'

Moon good; comparison good.

Measured by A.  
Power 17

Mean of Settings	Wave-Length, in Vacuum	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
		t. m.	t. m.	t. m.	t. m.	km.
S 28.5408	4415.250	.....	±0.000	4415.244	+0.006	+0.4
Ti 28.8334	4417.884	±0.000	.....	4417.884	.....	.....
Ti 29.8664	Standard	±0.000	.....	4427.266	.....	.....
S 29.8839	4427.426	.....	±0.000	4427.420	+0.006	+0.4
S 30.8023	4435.879	.....	+0.007	4435.851	+0.035	+2.4
S 31.5146	4442.508	.....	+0.013	4442.510	+0.011	+0.7
Ti 31.6639	4443.962	+0.014	.....	4443.976	.....	.....
S 31.6721	4443.983	.....	+0.014	4443.976	+0.021	+1.4
S 32.0600	4447.920	.....	-0.004	4447.892	+0.024	+1.6
Ti 32.2307	4449.323	-0.010	.....	4449.313	.....	.....
S 32.0485	4456.019	.....	-0.002	4456.030	+0.017	+1.1
Ti 33.1109	Standard	±0.000	.....	4457.600	.....	.....
S 34.1908	4457.656	.....	±0.000	4457.656	±0.000	±0.0
S 34.2306	4468.667	.....	-0.006	4468.663	-0.002	-0.1
Ti 34.2308	4468.669	-0.006	.....	4468.663	.....	.....
S 35.0632	4476.230	.....	±0.000	4476.314	+0.016	+1.1
Ti 35.5624	4481.434	-0.004	.....	4481.438	.....	.....
S 36.0685	4482.585	.....	+0.004	4482.376	+0.013	+0.9
S 36.8951	4494.737	.....	±0.000	4494.738	-0.001	-0.1
Ti 37.0518	Standard	±0.000	.....	4496.318	.....	.....
Ti 37.5576	4501.444	+0.001	.....	4501.445	.....	.....
S 37.5578	4501.446	.....	+0.001	4501.422	+0.025	+1.7

Curvature Cor. +0.0008 mm.

Mean +0.9 km.  
Computed Velocity +0.9

## MOON — B 363

1902, June 20, G. M. T. 18<sup>h</sup> 55<sup>m</sup>

Hour angle W 0° 50'

Moon fair; comparison good.

Measured by A.

Power 20

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
S 19.1323	4425.622	.....	±0.000	4425.608	+0.014	+1.0
<i>Ti</i> 19.3130	Standard	±0.000	.....	4427.266	.....	.....
S 19.3330	4427.448	.....	±0.000	4427.420	+0.028	+1.9
S 20.2503	4435.860	.....	+0.017	4435.851	+0.026	+1.8
S 20.9677	4442.513	.....	+0.029	4442.510	+0.032	+2.2
S 21.1205	4443.939	.....	+0.032	4443.976	-0.005	-0.3
<i>Ti</i> 21.1210	4443.944	+0.032	.....	4443.976	.....	.....
S 21.5405	4447.873	.....	+0.027	4447.892	+0.008	+0.5
<i>Ti</i> 21.6909	4449.288	+0.025	.....	4449.313	.....	.....
<i>Ti</i> 22.3462	Standard	±0.000	.....	4455.485	.....	.....
S 22.4025	4456.020	.....	+0.001	4456.030	-0.009	-0.6
S 23.7181	4468.645	.....	+0.034	4468.663	+0.016	+1.1
<i>Ti</i> 23.7164	4468.629	+0.034	.....	4468.663	.....	.....
S 24.4939	4476.201	.....	+0.020	4476.214	+0.007	+0.5
<i>Ti</i> 25.0256	4481.427	+0.011	.....	4481.438	.....	.....
S 25.1198	4482.358	.....	+0.011	4482.376	-0.007	-0.5
S 26.3633	4494.754	.....	+0.015	4494.738	+0.031	+2.1
<i>Ti</i> 26.5171	4496.302	+0.016	.....	4496.318	.....	.....
S 26.5898	4497.036	.....	+0.016	4497.052	+0.006	+0.4
S 27.0243	4501.434	.....	±0.000	4501.422	+0.012	+0.8
<i>Ti</i> 27.0254	Standard	±0.000	.....	4501.445	.....	.....

Curvature Cor. +0.0008 mm.

Mean +0.8 km.

Computed Velocity +0.2

## MOON — B 363

Measured by F.

Power 23

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
<i>Ti</i> 30.6616	Standard	±0.000	.....	4427.266	.....	.....
S 30.6809	4427.442	.....	-0.000	4427.420	+0.022	+1.5
<i>Ti</i> 31.4173	4434.189	-0.021	.....	4434.168	.....	.....
S 31.5268	4435.199	.....	-0.021	4435.184	-0.006	-0.4
S 32.3159	4442.536	.....	-0.004	4442.510	+0.022	+1.5
<i>Ti</i> 32.4724	4443.977	-0.001	.....	4443.976	.....	.....
S 32.4726	4443.978	.....	-0.001	4443.976	+0.001	+0.1
S 32.8904	4447.893	.....	-0.009	4447.892	-0.008	-0.5
<i>Ti</i> 33.0428	4449.327	-0.014	.....	4449.313	.....	.....
S 33.3024	4451.776	.....	-0.016	4451.752	+0.008	+0.5
<i>Ti</i> 33.6958	4455.503	-0.018	.....	4455.485	.....	.....
S 33.7513	4456.031	.....	-0.018	4456.030	-0.017	-1.1
<i>Ti</i> 34.7906	4465.985	-0.010	.....	4465.975	.....	.....
S 35.0678	4468.664	.....	-0.014	4468.663	-0.013	-0.9
<i>Ti</i> 35.3524	4471.426	-0.018	.....	4471.408	.....	.....
S 35.8438	4476.220	.....	-0.009	4476.214	-0.003	-0.2
<i>Ti</i> 36.3748	Standard	±0.000	.....	4481.438	.....	.....
S 36.4713	4482.390	.....	±0.000	4482.375	+0.015	+1.0
S 37.7111	4494.742	.....	-0.003	4494.738	+0.001	+0.1
<i>Ti</i> 37.8680	4496.321	-0.003	.....	4496.318	.....	.....
S 37.9397	4497.044	.....	-0.003	4497.046	-0.005	-0.3
S 38.3715	4501.412	.....	+0.010	4501.448	-0.026	-1.7
<i>Ti</i> 38.3741	4501.438	+0.010	.....	4501.448	.....	.....
S 39.0627	4508.459	.....	-0.002	4508.455	+0.002	+0.1
<i>Ti</i> 39.4964	4512.917	-0.011	.....	4512.906	.....	.....
S 40.2157	4520.372	.....	-0.002	4520.397	-0.027	-1.8
<i>Ti</i> 40.4650	Standard	±0.000	.....	4522.974	.....	.....
S 40.4530	4522.849	.....	±0.000	4522.871	-0.022	-1.5
<i>Ti</i> 40.8955	4527.489	+0.001	.....	4527.490	.....	.....
S 41.0209	4528.810	.....	+0.001	4528.798	+0.013	+0.9

Curvature Cor. +0.0013 mm.

Mean -0.2 km.

Computed Velocity +0.2

## MOON—A 350

1902, July 16, G. M. T. 14<sup>h</sup> 28<sup>m</sup>  
Hour angle E. 0° 42'

Moon fair; comparison fair.

Measured by A.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
Ti 29.3369	Standard	+0.000	.....	4427.266	.....	.....
S 29.3552	.....	.....	+0.000	4427.420	+0.034	+2.3
S 30.9807	4435.178	.....	+0.006	4435.184	±0.000	±0.0
S 31.5670	4442.498	.....	+0.012	4442.510	±0.000	±0.0
Ti 31.6896	4443.963	+0.013	.....	4443.976	.....	.....
S 31.9948	4447.891	.....	-0.004	4447.892	-0.005	-0.3
Ti 32.1081	4449.323	-0.010	.....	4449.313	.....	.....
Ti 32.5937	4455.506	-0.021	.....	4455.485	.....	.....
S 32.6396	4456.055	.....	-0.021	4456.030	+0.004	+0.3
Ti 33.6143	4468.682	-0.019	.....	4468.663	.....	.....
S 34.1884	4476.204	.....	-0.008	4476.214	-0.018	-1.2
Ti 34.5813	Standard	±0.000	.....	4481.438	.....	.....
S 34.6546	4482.372	.....	-0.001	4482.376	-0.005	-0.3
S 35.5784	4494.753	.....	-0.010	4494.738	+0.005	+0.3
Ti 35.6948	4496.329	-0.011	.....	4496.318	.....	.....
S 35.7484	4497.055	.....	-0.011	4497.046	-0.002	-0.1
S 36.0693	4501.421	.....	-0.013	4501.422	-0.014	-0.9
Ti 36.0720	4501.458	-0.013	.....	4501.445	.....	.....
S 37.0281	4514.625	.....	-0.006	4514.617	+0.002	+0.1
Ti 37.9457	Standard	+0.000	.....	4527.490	.....	.....
S 38.0405	4528.832	.....	-0.001	4528.798	+0.033	+2.2
S 38.4194	4534.221	.....	-0.010	4534.168	+0.043	+2.8
Ti 38.4714	4534.964	-0.011	.....	4534.953	.....	.....

Curvature Cor. +0.0005 mm.

Mean +0.4 km.

Computed Velocity +0.4

## MOON—B 401

1902, August 27, G. M. T. 21<sup>h</sup> 47<sup>m</sup>  
Hour angle E. 3° 14'

Moon slightly weak; comparison fair.

Measured by A.  
Power 28

S 29.0862	4425.591	.....	±0.000	4425.608	-0.017	-1.2
Ti 29.2702	Standard	+0.000	.....	4427.266	.....	.....
S 29.2843	4427.395	.....	±0.000	4427.420	-0.025	-1.7
S 30.9248	4442.512	.....	+0.003	4442.510	+0.005	+0.3
S 31.0788	4443.948	.....	+0.003	4443.976	-0.025	-1.7
Ti 31.0814	4443.973	+0.003	.....	4443.976	.....	.....
S 31.4988	4447.881	.....	-0.001	4447.892	-0.010	-0.7
Ti 31.6510	4449.312	+0.001	.....	4449.313	.....	.....
Ti 32.3053	4455.495	-0.010	.....	4455.485	.....	.....
S 32.3612	4456.026	.....	-0.010	4456.030	-0.014	-0.9
S 33.6784	4468.651	.....	-0.018	4468.663	-0.030	-2.0
Ti 33.6815	4468.681	-0.018	.....	4468.663	.....	.....
S 34.4546	4476.208	.....	-0.008	4476.214	-0.014	-0.9
Ti 34.5896	Standard	+0.000	.....	4481.438	.....	.....
S 35.0827	4482.395	.....	±0.000	4482.376	-0.011	-0.7
S 36.7243	4494.714	.....	-0.003	4494.738	-0.027	-1.8
S 36.0885	4501.408	.....	-0.005	4501.422	-0.019	-1.3
Ti 36.9927	4501.454	-0.005	.....	4501.445	.....	.....
S 39.0727	4522.824	.....	+0.003	4522.853	-0.026	-1.7
Ti 39.0898	4522.971	+0.003	.....	4522.974	.....	.....
S 39.3065	4525.295	.....	+0.001	4525.285	-0.018	-1.2
Ti 39.5187	Standard	±0.000	.....	4527.490	.....	.....
S 39.6431	4528.797	.....	±0.000	4528.798	-0.001	-0.1

Curvature Cor. +0.0008 mm.

Mean -1.1 km.

Computed Velocity -1.5

## MOON — B 408

1902, September 13, G. M. T. 16<sup>h</sup> 13<sup>m</sup>  
Hour angle W 1<sup>h</sup> 14<sup>m</sup>

Moon good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
<i>Ti</i> 31.7436	Standard	+0.000	.....	4427.266		
S 31.7599	4427.415	.....	±0.000	4427.420	-0.005	-0.3
S 32.4112	4433.390	.....	+0.005	4433.390	+0.005	+0.3
S 33.3929	4442.495	.....	+0.011	4442.510	-0.004	-0.3
S 33.5520	4443.982	.....	+0.012	4443.976	+0.018	+1.2
<i>Ti</i> 33.5501	4443.964	+0.012	.....	4443.976		
S 33.9700	4447.904	.....	+0.005	4447.892	+0.017	+1.2
<i>Ti</i> 34.1194	4449.311	+0.002	.....	4449.313		
<i>Ti</i> 34.7714	4455.486	-0.001	.....	4455.485		
S 34.8303	4456.046	.....	-0.001	4456.030	+0.015	+1.0
<i>Ti</i> 34.9933	Standard	±0.000	.....	4457.600		
S 34.9984	4457.648	.....	±0.000	4457.656	-0.008	-0.5
<i>Ti</i> 36.1445	4468.671	-0.008	.....	4468.663		
S 36.1456	4468.682	.....	-0.008	4468.663	+0.011	+0.7
S 36.9185	4476.214	.....	-0.006	4476.214	-0.006	-0.4
<i>Ti</i> 37.4503	4481.443	-0.005	.....	4481.438		
S 37.5453	4482.381	.....	±0.005	4482.376	±0.000	±0.0
S 38.7829	4494.718	.....	±0.000	4494.738	-0.020	-1.3
<i>Ti</i> 38.9418	Standard	±0.000	.....	4496.318		
S 39.0126	4497.032	.....	±0.000	4497.046	-0.14	-0.9

Curvature Cor. + 0.0009 m.

Mean + 0.1 km.

Computed Velocity + 0.2

## MOON — B 423

1902, October 15, G. M. T. 15<sup>h</sup> 44<sup>m</sup>  
Hour angle E 1<sup>h</sup> 1<sup>m</sup>

Moon good; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 33.6163	Standard	±0.000	.....	4427.266		
S 33.6324	4427.413	.....	±0.000	4427.420	-0.007	-0.5
S 35.2019	4441.876	.....	+0.006	4441.881	+0.001	+0.1
S 35.2673	4442.485	.....	+0.006	4442.510	-0.019	-1.3
S 35.4234	4443.942	.....	+0.007	4443.976	-0.025	-1.7
<i>Ti</i> 35.4262	4443.969	+0.007	.....	4443.976		
S 35.8448	4447.891	.....	+0.005	4447.892	+0.004	+0.3
<i>Ti</i> 35.9656	4449.309	+0.004	.....	4449.313		
<i>Ti</i> 36.6475	4455.475	+0.010	.....	4455.485		
S 36.7044	4456.016	.....	+0.007	4456.030	-0.007	-0.5
<i>Ti</i> 36.8708	Standard	±0.000	.....	4457.600		
S 36.8771	4457.660	.....	±0.000	4457.656	+0.004	+0.3
S 38.0184	4468.625	.....	+0.006	4468.663	-0.032	-2.1
<i>Ti</i> 38.0218	4468.657	+0.006	.....	4468.663		
S 38.7970	4476.206	.....	+0.011	4476.214	+0.003	+0.2
<i>Ti</i> 39.3279	4481.423	+0.015	.....	4481.438		
S 39.4226	4482.357	.....	+0.015	4482.376	-0.004	-0.3
S 40.6621	4494.707	.....	+0.017	4494.738	-0.014	-0.9
<i>Ti</i> 40.8205	4496.301	+0.017	.....	4496.318		
S 40.8926	4497.028	.....	+0.015	4497.046	-0.003	-0.2
S 41.3250	4501.401	.....	±0.000	4501.422	-0.021	-1.4
<i>Ti</i> 41.3293	Standard	±0.000	.....	4501.445		

Curvature Cor. + 0.0008 mm.

Mean - 0.6 km.

Computed Velocity - 0.4

## MOON - B 444

1902, November 6, G. M. T. 13<sup>h</sup> 38<sup>m</sup>  
Hour angle W 2<sup>h</sup> 54<sup>m</sup>

Moon good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
Ti 34.0106	Standard	± 0.000		4427.266		
S 34.0322			± 0.000	4427.420	-0.002	-0.1
S 34.0802			-0.014	4433.390	+0.006	+0.4
Ti 34.7701		-0.016		4434.168		
S 34.9510			-0.010	4435.851	-0.005	-0.3
S 35.0659			+0.012	4442.510	+0.006	+0.4
Ti 35.8214		+0.017		4443.976		
S 35.8245			+0.017	4443.976	+0.029	+2.0
S 36.2407			+0.005	4447.892	+0.010	+0.6
Ti 36.3907		+0.001		4449.313		
Ti 37.0401		+0.014		4455.485		
S 37.1005			+0.010	4456.030	+0.027	+1.8
Ti 37.2632	Standard	± 0.000		4457.600		
S 37.2718			± 0.000	4457.656	+0.026	+1.7
S 38.4118			-0.009	4468.663	-0.004	-0.3
Ti 38.4123		-0.009		4468.663		
S 39.1858			+0.008	4476.214	+0.022	+1.5
Ti 39.7123		+0.019		4481.438		
S 39.8069			+0.018	4482.376	-0.002	-0.1
S 41.0457			+0.002	4494.738	+0.007	+0.5
Ti 41.2016	Standard	± 0.000		4496.318		
S 41.2751			± 0.000	4497.046	+0.015	+1.0
S 41.7048			+0.001	4501.422	+0.004	+0.3
Ti 41.7067		+0.001		4501.445		

Curvature Cor. +0.0009 mm.

Mean +0.7 km.  
Computed Velocity +0.6*a* ARIETISThe plate of *a Arietis* given below was previously published in Frost's paper on the Bruce spectrograph<sup>15</sup> as an example of the method of reduction.*a* ARIETIS—B 2331901, November 15, G. M. T. 14<sup>h</sup> 36<sup>m</sup>  
Hour angle E 1<sup>h</sup> 40<sup>m</sup>

Star good; comparison strong.

Measured by A.  
Power 21

S 28.0279	4442.418	.....	+0.015	4442.510	-0.077	-5.2
S 28.1850	4443.880	.....	+0.015	4443.976	-0.081	5.5
Ti 28.1937	4443.961	+0.015		4443.976		
S 28.6055	4447.808	.....	+0.004	4447.892	-0.080	5.4
Ti 28.7659	Standard	± 0.000		4449.313		
S 29.0187	4451.691	.....	-0.001	4451.752	-0.062	4.2
Ti 29.6496	4457.604	-0.004		4457.600		
S 30.7931	4468.614	.....	-0.004	4468.663	-0.053	3.6
Ti 30.7987	4468.667	-0.004		4468.663		
S 31.5695	4476.148	.....	+0.003	4476.214	-0.063	4.2
Ti 32.1089	4481.431	+0.007		4481.438		
S 32.1972	4482.300	.....	+0.006	4482.376	-0.070	4.7
Ti 32.8241	4488.497	-0.004		4488.493		
S 33.4467	4494.705	.....	-0.016	4494.738	-0.049	3.3
Ti 33.6065	4496.337	-0.019		4496.318		
S 34.1050	4501.329	.....	-0.003	4501.422	-0.096	6.4
Ti 34.1198	4501.448	-0.003		4501.445		
S 35.2379	4512.873	.....	-0.014	4512.906	-0.047	3.1
Ti 35.2425	4512.920	-0.014		4512.906		
S 35.4846	4515.411	.....	-0.012	4515.475	-0.076	5.1
Ti 36.6468	Standard	+0.000		4527.490		
S 36.7676	4528.757	.....	-0.006	4528.798	-0.047	3.1
S 37.3481	4534.877	.....	-0.033	4534.953	-0.109	7.2
Ti 37.3585	4534.986	-0.033		4534.953		
Ti 38.2802	4544.874	-0.010		4544.861		
S 38.3976	4546.071	.....	-0.009	4546.129	-0.067	4.4

$\alpha$  ARIETIS—B 233 *Continued*

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
<i>Ti</i> 39.0060	4552.639	-0.007	.....	4552.632	.....	.....
<i>S</i> 39.1432	4554.128	.....	-0.013	4554.211	-0.096	6.3
<i>Ti</i> 39.2861	4555.682	-0.020	.....	4555.662	.....	.....
<i>S</i> 40.0346	4563.876	.....	-0.006	4563.939	-0.069	4.5
<i>Ti</i> 40.0409	4563.945	-0.006	.....	4563.939	.....	.....
<i>S</i> 40.6947	4571.177	.....	-0.002	4571.275	-0.100	6.6
<i>S</i> 40.7752	4572.072	.....	-0.002	4572.156	-0.086	5.6
<i>Ti</i> 40.7829	4572.158	-0.002	.....	4572.156	.....	.....
<i>S</i> 41.2421	4577.286	.....	-0.007	4577.356	-0.077	5.0
<i>S</i> 42.3755	4590.093	.....	-0.020	4590.126	-0.053	3.5
<i>Ti</i> 42.3801	4590.146	-0.020	.....	4590.126	.....	.....
<i>S</i> 44.6303	4616.228	.....	-0.001	4616.305	-0.078	5.1
<i>S</i> 44.7282	4617.383	.....	$\pm 0.000$	4617.452	-0.069	4.5
<i>Ti</i> 44.7340	Standard	$\pm 0.000$	.....	4617.452	.....	.....

Curvature Cor. +0.0008 mm.

Mean  $-4.8$  $V_a -8.91$  $V_d +0.13$ Reduction to Sun  $-8.78$ Radial Velocity  $-13.6$  km.

The results of other observers for this star are as follows:

Vogel	-	-	-	-	-	-14.5
Scheiner	-	-	-	-	-	-14.9
Lord	-	-	-	-	-	-14.0
Campbell	-	-	-	-	-	-14.1

 $\alpha$  TAURI

Two plates of this star have been measured, both by A. Of these B 191 is slightly inferior for measurement on account of the narrowness of its star spectrum, the photograph having been taken previous to the change of windows in the occulting bar.

 $\alpha$  TAURI—B 1911901, September 4, G. M. T. 20<sup>h</sup> 0<sup>m</sup>  
Hour angle E 3<sup>h</sup> 27<sup>m</sup>

Star good; comparison fair.

Measured by A. with Zeiss Comparator  
Power 20

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm	t. m.	t. m.	t. m.	t. m.	t. m.	km
<i>Ti</i> 46.0655	Standard	$\pm 0.000$	.....	4457.600	.....	.....
<i>S</i> 46.0170	4458.060	.....	-0.000	4457.656	+0.404	+27.2
<i>Ti</i> 44.9084	4468.656	+0.007	.....	4468.663	.....	.....
<i>S</i> 44.0847	4476.633	.....	-0.025	4476.214	+0.394	26.4
<i>Ti</i> 43.5887	4481.480	-0.042	.....	4481.438	.....	.....
<i>Ti</i> 41.5760	4501.488	-0.043	.....	4501.445	.....	.....
<i>S</i> 41.5383	4501.868	.....	-0.043	4501.422	+0.403	26.8
<i>S</i> 40.4909	4512.508	.....	-0.074	4512.063	+0.371	24.7
<i>Ti</i> 40.4446	4512.982	0.076	.....	4512.906	.....	.....
<i>S</i> 40.4064	4513.373	.....	-0.076	4512.906	+0.391	26.0
<i>Ti</i> 39.9322	4518.248	-0.050	.....	4518.198	.....	.....
<i>S</i> 39.8965	4518.616	.....	-0.050	4518.198	+0.368	24.4
<i>Ti</i> 39.4690	4523.041	-0.067	.....	4522.974	.....	.....
<i>S</i> 39.0793	4527.097	.....	-0.069	4526.644	+0.384	25.4
<i>Ti</i> 39.0350	4527.559	0.069	.....	4527.490	.....	.....
<i>S</i> 38.9948	4527.979	.....	-0.069	4527.518	+0.392	26.0
<i>S</i> 38.8704	4529.280	.....	-0.064	4528.798	+0.418	27.7
<i>S</i> 38.4366	4533.831	.....	-0.051	4533.419	+0.367	24.3
<i>Ti</i> 38.3261	4535.000	-0.047	.....	4534.953	.....	.....
<i>Ti</i> 37.3919	4544.921	-0.057	.....	4544.864	.....	.....
<i>S</i> 37.3562	4545.303	.....	-0.057	4544.864	+0.382	25.2
<i>S</i> 37.2345	4546.606	.....	-0.065	4546.129	+0.412	27.2
<i>Ti</i> 37.0099	4549.016	-0.078	.....	4548.938	.....	.....
<i>S</i> 36.9726	4549.417	.....	-0.078	4548.938	+0.401	26.4

*a TAURI—B 191—Continued*

Mean of Settings	Wave-Length, by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.	mm.	mm.	mm.	mm.	mm.	km.
S 36.8060	4550.241	.....	-0.069	4549.767	+0.405	26.7
S 36.4873	4554.654	.....	-0.055	4554.211	+0.388	25.6
Ti 36.3896	4555.713	-0.051	.....	4555.662	.....	.....
S 36.3502	4556.140	.....	-0.051	4555.662	+0.427	28.1
Ti 35.6352	Standard	-0.000	.....	4563.939	.....	.....
S 35.4341	4566.147	.....	+0.002	4565.750	+0.399	26.2
S 34.9308	4571.700	.....	+0.006	4571.275	+0.431	28.3
Ti 34.8903	4572.150	+0.006	.....	4572.156	.....	.....
S 34.8516	4572.579	.....	+0.006	4572.156	+0.429	28.1
S 32.1946	4602.620	.....	-0.007	4602.183	+0.430	28.0
S 30.9806	4616.743	.....	-0.014	4616.305	+0.424	27.5
Ti 30.9191	4617.466	-0.014	.....	4617.452	.....	.....
S 30.8819	4617.903	.....	-0.014	4617.452	+0.437	28.4
Ti 30.4227	4623.321	-0.042	.....	4623.279	.....	.....
S 29.5666	4633.520	.....	-0.035	4633.078	+0.407	26.3
S 28.0527	4651.883	.....	-0.021	4651.461	+0.401	25.8
S 27.9800	4652.777	.....	-0.020	4652.343	+0.414	26.7
Ti 27.6645	4656.662	-0.018	.....	4656.644	.....	.....
S 27.6303	4657.083	.....	-0.018	4656.644	+0.421	27.1
S 27.0799	4663.910	.....	-0.005	4663.481	+0.424	27.3
Ti 26.7709	Standard	±0.000	.....	4667.768	.....	.....

Curvature Cor. +0.0002 mm.

Mean  $V_a$  +26.6 $V_d$  +29.29  
+ 0.26

Reduction to Sun +29.55

Radial Velocity +56.1 km.

*a TAURI—B 275*1902, January 16, G. M. T. 16<sup>h</sup> 15<sup>m</sup>  
Hour angle E 0° 33'

Star good; comparison good.

Measured by A.  
Power 20

Ti 29.0002	Standard	±0.000	.....	4417.884	.....	.....
S 29.3656	4421.203	.....	+0.015	4420.100	+1.118	+75.9
Ti 30.0248	4427.231	+0.035	.....	4427.266	.....	.....
S 31.0761	4436.956	.....	+0.020	4435.851	+1.125	76.1
S 31.7232	4443.012	.....	+0.009	4441.881	+1.140	77.0
S 31.7063	4443.671	.....	+0.008	4442.510	+1.169	78.9
Ti 31.8249	4443.968	+0.008	.....	4443.976	.....	.....
Ti 31.9487	4445.134	.....	+0.008	4443.976	+1.166	78.7
S 32.3640	4449.061	.....	+0.009	4447.892	+1.178	79.4
Ti 32.3897	4449.304	+0.009	.....	4449.313	.....	.....
Ti 33.2583	4457.591	+0.009	.....	4457.600	.....	.....
S 33.6781	4461.632	.....	-0.015	4460.460	+1.157	77.8
S 33.8214	4463.017	.....	-0.024	4461.818	+1.175	79.0
Ti 33.9000	4464.650	-0.033	.....	4464.617	.....	.....
S 34.2228	4467.883	.....	-0.009	4466.701	+1.173	78.7
Ti 34.1662	4468.667	-0.004	.....	4468.663	.....	.....
S 35.2905	4477.372	.....	-0.001	4476.214	+1.157	77.5
Ti 35.7012	Standard	±0.000	.....	4481.438	.....	.....
S 35.9172	4483.586	.....	-0.007	4482.376	+1.203	80.5
Ti 36.4875	4489.288	-0.026	.....	4489.262	.....	.....
S 36.9670	4491.101	.....	-0.030	4489.911	+1.160	77.5
Ti 37.6928	4501.490	-0.045	.....	4501.445	.....	.....
S 37.8938	4502.621	.....	-0.045	4501.422	+1.157	77.1
S 38.1701	4506.209	.....	-0.030	4505.003	+1.176	78.3
Ti 38.8029	4512.914	-0.008	.....	4512.906	.....	.....
S 38.9166	4514.064	.....	-0.008	4512.906	+1.180	78.4
Ti 40.1942	Standard	±0.000	.....	4527.490	.....	.....
S 40.2295	4527.833	.....	±0.000	4526.644	+1.189	78.8
S 40.4312	4530.002	.....	±0.000	4528.798	+1.204	79.7

Curvature Cor. +0.0008 mm.

Mean  $V_a$  +78.1 $V_d$  -22.16  
+ 0.04

Reduction to Sun -22.12

Radial Velocity +56.0 km.

SUMMARY OF MEASURES OF  $\alpha$  TAURI

Plate	Date	Adams	No. of Lines
B 191	1901, Sept. 4	+56.1	27
B 275	1902, Jan. 16	+56.0	16
Mean		+56.1 km.	

The results of other observers for this star are as follows:

Vogel	-	-	-	-	-	+47.6
Scheiner	-	-	-	-	-	+49.4
Keeler (visual)	-	-	-	-	-	+55.2
Campbell	-	-	-	-	-	+54.8

 $\alpha$  BOÖTIS

Eight plates of this star have been measured, six by A. and four by F., giving results in good agreement. The plates are nearly all of excellent quality, with those of Series B somewhat superior for purposes of measurement.

1902, March 12, G. M. T. 18<sup>h</sup> 13<sup>m</sup>  
Hour angle E 2<sup>h</sup> 28<sup>m</sup>

$\alpha$  BOÖTIS—B 293

Star good; comparison good.

Measured by A.  
Power 20

Mean of Settings		Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.		t. m.	t. m.	t. m.	t. m.	t. m.	km.
Ti	29.4878	Standard	$\pm 0.000$	.....	4427.266		
S	29.6177	4428.456	.....	+0.001	4428.711	-0.254	-17.2
S	30.3878	4435.554	.....	-0.008	4435.851	-0.289	19.5
S	31.0376	4441.602	.....	+0.015	4441.881	-0.264	17.8
S	31.1051	4442.234	.....	-0.015	4442.510	-0.261	17.6
S	31.2019	4443.702	.....	+0.017	4443.976	-0.257	17.3
Ti	31.2893	4443.959	+0.017	.....	4443.976		
S	31.6819	4447.652	.....	-0.001	4447.892	-0.241	16.2
Ti	31.8588	4449.323	-0.010	.....	4449.313		
S	32.0882	4451.495	.....	-0.006	4451.752	-0.263	17.7
Ti	32.7282	4457.592	+0.008	.....	4457.600		
S	32.9457	4459.676	.....	+0.006	4459.922	-0.240	16.1
S	33.0402	4466.432	.....	+0.001	4466.701	-0.268	18.0
S	33.8510	4468.420	.....	$\pm 0.000$	4468.663	-0.243	16.3
Ti	33.8700	Standard	$\pm 0.000$	.....	4468.663		
S	34.6232	4475.965	.....	-0.004	4476.214	-0.252	16.9
Ti	35.1786	4481.444	-0.006	.....	4481.438		
S	35.2907	4482.644	.....	-0.005	4482.904	-0.265	17.7
S	36.4837	4494.487	.....	$\pm 0.000$	4494.738	-0.251	16.8
S	36.7112	4496.786	.....	+0.001	4497.046	-0.259	17.3
S	37.1419	4501.158	.....	+0.003	4501.422	-0.261	17.4
Ti	37.1698	4501.442	+0.003	.....	4501.445		
S	38.2623	4512.657	.....	-0.020	4512.906	-0.269	17.9
Ti	38.2883	4512.926	-0.020	.....	4512.906		
S	38.7248	4517.458	.....	-0.011	4517.702	-0.255	16.9
S	38.7700	4517.930	.....	-0.009	4518.198	-0.277	18.4
Ti	38.7966	4518.207	-0.009	.....	4518.198		
Ti	39.2524	4522.975	-0.001	.....	4522.974		
Ti	39.6814	Standard	$\pm 0.000$	.....	4527.490		
S	39.7821	4528.556	.....	-0.005	4528.798	-0.247	16.4
S	40.2876	4533.923	.....	-0.029	4534.168	-0.274	18.1
Ti	40.3106	4534.168	-0.029	.....	4534.139		
S	40.3596	4534.691	.....	-0.025	4534.953	-0.287	19.0
Ti	40.3865	4534.978	-0.025	.....	4534.953		

Curvature Cor. +0.0008 mm.

Mean  $-17.4$

$V_a +13.63$

$V_d + 0.19$

Reduction to Sun  $+13.82$

Radial Velocity  $- 3.6$  km.

$\alpha$  BOÖTIS B 3001902, March 13, G. M. T. 17<sup>h</sup> 29<sup>m</sup>  
Hour angle E 3<sup>h</sup> 12<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.	Å.	t. m.	t. m.	t. m.	t. m.	km.
Ti 30 4335	Standard	±0.000	.....	4427.266	.....	.....
S 31 0558	4433.163	.....	-0.001	4433.390	-0.228	-15.4
S 31 0839	4441.589	.....	-0.002	4441.881	-0.294	19.9
S 32 0515	4442.221	.....	-0.002	4442.510	-0.291	19.6
S 32 2103	4443.706	.....	-0.002	4443.976	-0.272	18.4
Ti 32 2383	4443.978	-0.002	.....	4443.976	.....	.....
S 32 6271	4447.621	.....	-0.008	4447.892	-0.279	18.8
Ti 32 8077	4449.324	-0.011	.....	4449.313	.....	.....
Ti 33 6573	4457.584	+0.016	.....	4457.600	.....	.....
S 33 8967	4459.684	.....	+0.013	4459.922	-0.225	15.1
S 34 0044	4461.552	.....	+0.010	4461.818	-0.256	17.2
S 34 0004	4466.461	.....	+0.003	4466.701	-0.237	15.9
S 34 8012	4468.408	.....	±0.000	4468.663	-0.255	17.1
Ti 34 8275	Standard	±0.000	.....	4468.663	.....	.....
S 35 5739	4475.948	.....	-0.009	4476.214	-0.275	18.4
Ti 36 1330	4481.454	-0.016	.....	4481.438	.....	.....
S 36 2010	4482.127	.....	-0.016	4482.376	-0.265	17.7
S 37 4307	4494.464	.....	-0.020	4494.738	-0.294	19.6
Ti 37 6226	4496.339	-0.021	.....	4496.318	.....	.....
S 37 6975	4496.793	.....	-0.021	4497.046	-0.274	18.3
S 38 0072	4501.148	.....	-0.005	4501.422	-0.279	18.6
Ti 38 1289	4501.450	-0.005	.....	4501.445	.....	.....
S 39 2306	4512.661	.....	+0.004	4512.906	-0.241	16.0
Ti 39 2440	4512.902	+0.004	.....	4512.906	.....	.....
S 39 7279	4517.921	.....	-0.009	4518.198	-0.288	19.0
Ti 39 7554	4518.207	-0.009	.....	4518.198	.....	.....
S 40 5344	4526.362	.....	-0.001	4526.644	-0.283	18.8
Ti 40 6444	Standard	±0.000	.....	4527.490	.....	.....
S 40 7169	4528.540	.....	±0.000	4528.798	-0.258	17.1

Curvature Cor. +0.0008 mm.

Mean -17.8

 $V_a + 13.26$  $V_d + 0.24$ 

Reduction to Sun

+13.50

Radial Velocity

-4.3 km.

 $\alpha$  BOÖTIS B 300Measured by F.  
Power 23

Ti 30 1742	Standard	±0.000	.....	4427.266	.....	.....
S 30 1583	4427.120	.....	±0.000	4427.420	-0.300	-20.3
S 30 8809	4433.757	.....	+0.015	4434.021	-0.249	16.8
Ti 30 9236	4434.152	+0.016	.....	4434.168	.....	.....
S 31 7920	4442.218	.....	-0.002	4442.510	-0.294	19.8
Ti 31 9804	4443.981	-0.005	.....	4443.976	.....	.....
S 32 3257	4447.600	.....	-0.022	4447.892	-0.314	21.2
Ti 32 5506	4449.343	-0.030	.....	4449.313	.....	.....
Ti 33 1593	4455.495	-0.010	.....	4455.485	.....	.....
S 33 2254	4455.729	.....	-0.015	4456.039	-0.301	20.3
Ti 33 4195	4457.596	+0.004	.....	4457.600	.....	.....
Ti 34 2590	4465.991	-0.016	.....	4465.975	.....	.....
S 34 5426	4468.418	.....	-0.011	4468.663	-0.256	17.2
Ti 34 5969	4468.674	-0.011	.....	4468.663	.....	.....
Ti 34 8959	4471.406	+0.002	.....	4471.408	.....	.....
S 34 8975	4471.568	.....	-0.004	4471.846	-0.282	18.9
S 35 3043	4475.927	.....	-0.002	4476.214	-0.289	19.4
Ti 35 8751	Standard	±0.000	.....	4481.438	.....	.....
S 35 9402	4482.101	.....	±0.000	4482.376	-0.275	18.4
S 37 1300	4494.453	.....	+0.004	4494.738	-0.301	20.1
Ti 37 3925	4496.318	+0.005	.....	4496.318	.....	.....
S 37 7492	4500.196	.....	+0.007	4500.451	-0.248	16.5

$\alpha$  BOÖTIS—B 300—Continued

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
S 39.4258	4517.444		+0.016	4517.702	-0.242	16.1
Ti 39.4968	4518.182	+0.016		4518.198		
S 40.2750	4526.323		+0.014	4526.644	-0.307	20.3
S 40.3614	4527.232		+0.014	4527.518	-0.272	18.0
Ti 40.3845	4527.476	+0.014		4527.490		
S 40.4819	4527.503		+0.014	4528.798	-0.281	18.6
Ti 42.0156	4544.866	-0.002		4544.864		
S 42.1032	4545.811		-0.003	4546.129	-0.314	20.7
S 42.2773	4547.695		-0.006	4548.024	-0.335	22.1
S 42.3652	4548.625		-0.008	4548.938	-0.321	21.2
Ti 42.3928	4548.946			4548.938		
Ti 42.7317	Standard	$\pm 0.000$		4552.632		
S 42.8497	4553.919		+0.005	4554.211	-0.287	18.9
Ti 43.0081	4555.649	+0.013		4555.662		

Curvature Cor. +0.0013 mm.

Mean -19.2

 $V_a +13.26$  $V_d +0.24$ 

Reduction to Sun +13.50

Radial Velocity -5.7 km.

 $\alpha$  BOÖTIS—A 3361902, March 26, G. M. T. 18<sup>h</sup> 58<sup>m</sup>

Hour angle E 0° 32'

Star good; comparison strong.

Measured by A.

Power 20

Ti 29.3151	Standard	$\pm 0.000$	.....	4427.266		
S 29.4149	4428.497		-0.003	4428.711	-0.217	-14.7
Ti 29.8737	4434.185	-0.017	.....	4434.168		
S 30.4712	4441.664	.....	-0.011	4441.881	-0.228	15.4
S 30.5237	4442.325	.....	-0.011	4442.510	-0.196	13.2
S 30.6378	4443.764	.....	-0.009	4443.976	-0.221	14.9
Ti 30.6553	4443.985	-0.009	.....	4443.976		
S 30.9494	4447.709	.....	-0.018	4447.892	-0.201	13.6
Ti 31.0772	4449.334	-0.021	.....	4449.313		
S 31.2509	4451.548	.....	-0.017	4451.752	-0.221	14.9
Ti 31.7235	4457.609	-0.009	.....	4457.600		
S 31.9310	4460.287	.....	-0.016	4460.460	-0.189	12.7
Ti 32.3716	4466.008	-0.033	.....	4465.975		
S 32.4110	4466.522	.....	-0.033	4466.701	-0.212	14.2
S 32.5634	4468.514	.....	-0.034	4468.663	-0.183	12.3
Ti 32.5774	4468.697	-0.034	.....	4468.663		
S 33.1346	4476.028	.....	-0.013	4476.214	-0.199	13.3
Ti 33.5420	Standard	$\pm 0.000$	.....	4481.438		
S 33.6004	4482.217	.....	-0.001	4482.376	-0.160	10.7
Ti 34.6475	4496.330	-0.012	.....	4496.318		
S 34.6870	4496.868	.....	-0.011	4497.046	-0.189	12.6
S 35.0058	4501.224	.....	-0.004	4501.422	-0.202	13.5
Ti 35.0222	4501.449	-0.004	.....	4501.445		
S 36.2164	4518.013	.....	-0.013	4518.198	-0.198	13.1
Ti 36.2305	4518.211	-0.013	.....	4518.198		
Ti 36.8874	Standard	$\pm 0.000$	.....	4527.490		
S 36.9675	4528.629	.....	-0.006	4528.798	-0.175	11.6
S 37.3447	4534.021	.....	-0.036	4534.168	-0.183	12.1
Ti 37.3555	4534.175	-0.036	.....	4534.139		
S 37.3954	4534.748	.....	-0.023	4534.953	-0.228	15.1
Ti 37.4113	4534.976	-0.023	.....	4534.953		

Curvature Cor. +0.0005 mm.

Mean -13.4

 $V_a +7.97$  $V_d +0.04$ 

Reduction to Sun +8.01

Radial Velocity -5.4 km.

1902, April 2, G. M. T. 15<sup>h</sup> 51<sup>m</sup>  
Hour angle E 3<sup>h</sup> 31<sup>m</sup>

$\alpha$  BOÖTIS—B 304

Star good; comparison good.

Measured by A.  
Power 20

Mean of Settings	Wave-Length by Interference	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
	t. m.	t. m.	t. m.	t. m.	t. m.	km.
<i>TV</i> 30 8022	Standard	$\pm 0.000$	.....	4427.266	.....	.....
<i>S</i> 31 0324	4428.551	.....	$\pm 0.000$	4428.711	-0.160	-10.8
<i>S</i> 31 8070	4435.695	.....	-0.002	4435.851	-0.158	10.7
<i>S</i> 32 1550	4441.729	.....	-0.003	4441.881	-0.155	10.5
<i>S</i> 32 5206	4442.371	.....	-0.003	4442.510	-0.142	9.6
<i>S</i> 32 6807	4443.844	.....	-0.004	4443.976	-0.136	9.2
<i>TV</i> 32 6952	4445.980	-0.004	.....	4445.976	.....	.....
<i>S</i> 33 10058	4447.749	.....	-0.007	4447.892	-0.150	10.1
<i>S</i> 33 2149	4449.205	.....	-0.009	4449.313	-0.117	7.9
<i>TV</i> 33 2623	4449.322	-0.009	.....	4449.313	.....	.....
<i>TV</i> 34 1327	4457.603	-0.003	.....	4457.600	.....	.....
<i>S</i> 34 2622	4459.803	.....	-0.002	4459.922	-0.121	8.1
<i>S</i> 34 5565	4461.671	.....	-0.002	4461.818	-0.149	10.0
<i>S</i> 35 2606	4468.541	.....	$\pm 0.000$	4468.663	-0.122	8.2
<i>TV</i> 35 2791	Standard	$\pm 0.000$	.....	4468.663	.....	.....
<i>S</i> 36 0388	4476.060	.....	$\pm 0.004$	4476.214	-0.120	8.0
<i>TV</i> 36 5803	4481.432	$\pm 0.006$	.....	4481.438	.....	.....
<i>S</i> 36 6922	4482.243	.....	$\pm 0.005$	4482.376	-0.128	8.6
<i>S</i> 37 4167	4489.763	.....	-0.003	4489.911	-0.151	10.1
<i>TV</i> 37 8073	4494.595	.....	-0.009	4494.738	-0.152	10.1
<i>TV</i> 38 0890	4496.329	-0.011	.....	4496.318	.....	.....
<i>S</i> 38 1273	4496.919	.....	-0.009	4497.046	-0.136	9.1
<i>S</i> 38 5503	4501.274	.....	$\pm 0.001$	4501.422	-0.147	9.8
<i>TV</i> 38 5730	4501.444	$\pm 0.001$	.....	4501.445	.....	.....
<i>S</i> 39 6769	4512.776	.....	$\pm 0.004$	4512.906	-0.126	8.4
<i>TV</i> 39 6890	4512.902	$\pm 0.004$	.....	4512.906	.....	.....
<i>S</i> 40 1840	4518.043	.....	$\pm 0.000$	4518.198	-0.155	10.3
<i>TV</i> 40 1989	Standard	$\pm 0.000$	.....	4518.198	.....	.....

Curvature Cor.  $+0.0008$  mm.

Mean  $V_a - 9.4$

$V_a + 5.04$   
 $V_d + 0.26$

Reduction to Sun  $+5.30$

Radial Velocity  $-4.1$  km.

$\alpha$  BOÖTIS—B 304

Measured by F.  
Power 17

<i>S</i> 29 1931	4399.778	.....	$\pm 0.000$	4399.903	-0.125	-8.5
<i>TV</i> 29 2110	Standard	$\pm 0.000$	.....	4399.935	.....	.....
<i>S</i> 29 9727	4406.606	.....	-0.010	4406.810	-0.154	10.5
<i>S</i> 29 1776	4411.165	.....	-0.019	4411.240	-0.094	6.4
<i>TV</i> 30 4881	4411.259	-0.019	.....	4411.240	.....	.....
<i>TV</i> 32 2585	4427.278	-0.012	.....	4427.266	.....	.....
<i>S</i> 32 3919	4427.307	.....	-0.012	4427.420	-0.125	8.5
<i>S</i> 33 8921	4442.402	.....	-0.016	4442.510	-0.124	8.4
<i>TV</i> 34 0619	4443.963	-0.017	.....	4443.976	.....	.....
<i>S</i> 34 1944	4447.780	.....	-0.027	4447.892	-0.139	9.4
<i>TV</i> 34 6301	4449.345	-0.032	.....	4449.313	.....	.....
<i>S</i> 34 7553	4450.511	.....	-0.029	4450.597	-0.115	7.8
<i>TV</i> 35 2782	4455.500	-0.015	.....	4455.485	.....	.....
<i>S</i> 35 1912	4457.535	.....	-0.015	4457.656	-0.136	9.2
<i>TV</i> 35 4965	4457.615	-0.015	.....	4457.600	.....	.....
<i>TV</i> 37 9474	Standard	$\pm 0.000$	.....	4481.438	.....	.....
<i>S</i> 38 9024	4482.280	.....	$\pm 0.000$	4482.376	-0.116	7.8
<i>S</i> 39 2947	4494.599	.....	-0.001	4494.738	-0.140	9.3
<i>TV</i> 39 1421	4496.319	-0.001	.....	4496.318	.....	.....
<i>S</i> 39 5256	4501.201	.....	-0.014	4501.422	-0.142	9.5
<i>TV</i> 39 9418	4501.450	-0.014	.....	4501.445	.....	.....
<i>S</i> 41 0166	4512.795	.....	-0.002	4512.906	-0.113	7.5
<i>TV</i> 41 0675	4512.908	-0.002	.....	4512.906	.....	.....
<i>TV</i> 42 1776	4527.473	$\pm 0.017$	.....	4527.490	.....	.....
<i>S</i> 42 5073	4528.695	.....	$\pm 0.015$	4528.798	-0.088	5.8

$\alpha$  BOÖTIS B 304 Continued

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
<i>Ti</i> 44.0811	4544.873	-0.009	.....	4544.864	.....	.....
<i>S</i> 44.1872	4546.020	.....	-0.008	4546.129	-0.117	7.7
<i>S</i> 44.4471	4548.838	.....	-0.005	4548.938	-0.105	6.9
<i>S</i> 44.9271	4554.071	.....	-0.001	4554.211	-0.141	9.3
<i>Ti</i> 45.0724	Standard	$\pm 0.000$	.....	4555.662	.....	.....

Mean -8.3  
 Curvature Cor. -0.87  
 $V_a + 5.04$   
 $V_d + 0.26$   
 Reduction to Sun +5.30  
 Radial Velocity -3.8 km.

1902, April 3, G. M. T. 15<sup>h</sup> 56<sup>m</sup>  
 Hour angle E 3<sup>h</sup> 15<sup>m</sup>

$\alpha$  BOÖTIS—B 311  
 Star excellent; comparison excellent.

Measured by F.  
 Power 17

<i>Ti</i> 29.2136	Standard	$\pm 0.000$	.....	4399.935	.....	.....
<i>S</i> 29.1950	4399.772	.....	$\pm 0.000$	4399.903	-0.131	-8.9
<i>S</i> 29.9756	4406.664	.....	-0.002	4406.810	-0.148	10.1
<i>S</i> 30.4744	4411.106	.....	-0.004	4411.240	-0.138	9.4
<i>Ti</i> 30.4898	4411.244	-0.004	.....	4411.240	.....	.....
<i>Ti</i> 32.2622	4427.279	-0.013	.....	4427.266	.....	.....
<i>S</i> 32.2639	4427.286	.....	-0.013	4427.420	-0.147	10.0
<i>S</i> 33.8967	4442.393	.....	$\pm 0.000$	4442.510	-0.117	7.9
<i>Ti</i> 34.0658	4443.976	$\pm 0.000$	.....	4443.976	.....	.....
<i>S</i> 34.4718	4447.794	.....	-0.017	4447.892	-0.115	7.8
<i>Ti</i> 34.6350	4449.334	-0.021	.....	4449.313	.....	.....
<i>S</i> 34.7568	4450.486	.....	-0.018	4450.597	-0.129	8.7
<i>Ti</i> 35.2843	4455.496	-0.011	.....	4455.485	.....	.....
<i>S</i> 35.4991	4457.547	.....	-0.008	4457.656	-0.117	7.9
<i>Ti</i> 35.5055	4457.608	-0.008	.....	4457.600	.....	.....
<i>Ti</i> 37.9557	Standard	$\pm 0.000$	.....	4481.438	.....	.....
<i>S</i> 38.0400	4482.273	.....	-0.001	4482.376	-0.104	7.0
<i>S</i> 39.2742	4494.602	.....	-0.015	4494.738	-0.151	10.1
<i>Ti</i> 39.4459	4496.335	-0.017	.....	4496.318	.....	.....
<i>S</i> 39.9335	4501.277	.....	-0.016	4501.422	-0.161	10.7
<i>Ti</i> 39.9516	4501.461	-0.016	.....	4501.445	.....	.....
<i>S</i> 41.0574	4512.800	.....	+0.007	4512.906	-0.099	6.6
<i>Ti</i> 41.0670	4512.899	+0.007	.....	4512.906	.....	.....
<i>Ti</i> 44.0912	4544.848	+0.016	.....	4544.864	.....	.....
<i>S</i> 44.1983	4546.005	.....	+0.014	4546.129	-0.110	7.3
<i>S</i> 44.4581	4548.820	.....	+0.010	4548.938	-0.108	7.1
<i>S</i> 44.9415	4554.086	.....	+0.002	4554.211	-0.123	8.1
<i>Ti</i> 45.0855	Standard	$\pm 0.000$	.....	4555.662	.....	.....

Curvature Cor. +0.0012 mm.

Mean -8.4  
 $V_a + 4.60$   
 $V_d + 0.24$   
 Reduction to Sun +4.84  
 Radial Velocity -3.6 km.

1902 May 7, G. M. T. 17<sup>h</sup> 17<sup>m</sup>  
 Hour angle W 0<sup>h</sup> 17<sup>m</sup>

$\alpha$  BOÖTIS—B 342  
 Star good; comparison good.

Measured by F.  
 Power 17

<i>Ti</i> 30.001	Standard	$\pm 0.000$	.....	4427.266	.....	.....
<i>S</i> 30.029	4427.530	.....	0.000	4427.420	+0.110	+7.4
<i>S</i> 30.751	4434.147	.....	-0.025	4434.021	+0.101	6.8
<i>Ti</i> 30.756	4434.193	-0.025	.....	4434.168	.....	.....
<i>S</i> 32.238	4447.981	.....	-0.005	4447.892	+0.084	5.7
<i>Ti</i> 32.380	4449.317	-0.004	.....	4449.313	.....	.....

$\alpha$  BOÖTIS—B 342—Continued

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Moon Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
S 32.989	4455.075	.....	-0.016	4454.993	+0.066	4.4
Ti 33.034	4455.503	-0.018	.....	4455.485	.....	.....
Ti 33.254	4457.596	+0.004	.....	4457.600	.....	.....
S 33.269	4457.740	.....	+0.004	4457.656	+0.088	5.9
Ti 34.127	4465.967	+0.008	.....	4465.975	.....	.....
S 34.418	4468.780	.....	+0.008	4468.663	+0.125	8.4
S 35.189	4476.288	.....	+0.010	4476.214	+0.084	5.6
Ti 35.712	4481.427	+0.011	.....	4481.438	.....	.....
S 35.818	4482.473	.....	+0.011	4482.376	+0.108	7.3
S 37.056	4494.809	.....	+0.001	4494.738	+0.072	4.8
Ti 37.206	Standard	$\pm 0.000$	.....	4496.318	.....	.....
S 37.716	4501.479	.....	+0.002	4501.422	+0.059	3.9
S 38.844	4513.012	.....	+0.006	4512.906	+0.112	7.4
Ti 40.233	4527.478	+0.012	.....	4527.490	.....	.....
S 40.246	4527.615	.....	+0.012	4527.518	+0.109	7.2
S 40.369	4528.910	.....	+0.012	4528.798	+0.124	8.2
Ti 41.865	4544.852	+0.012	.....	4544.864	.....	.....
S 41.992	4546.222	.....	+0.010	4546.129	+0.103	6.8
S 42.736	4554.297	.....	+0.001	4554.211	+0.087	5.7
Ti 42.861	Standard	$\pm 0.000$	.....	4555.662	.....	.....

Curvature Cor. +0.001 mm.

Mean  $V_a$  +6.4 $V_a$  -9.90 $V_d$  -0.03

Reduction to Sun -9.93

Radial Velocity -3.6 km.

 $\alpha$  BOÖTIS—B 3711902, June 26, G. M. T. 15<sup>h</sup> 30<sup>m</sup>Hour angle W 1<sup>h</sup> 34<sup>m</sup>

Star slightly weak; comparison good.

Measured by A.

Power 17

Ti 32.6666	Standard	$\pm 0.000$	.....	4427.266	.....	.....
S 32.8568	4429.004	.....	$\pm 0.000$	4428.711	+0.293	+19.8
S 34.3503	4442.805	.....	$\pm 0.000$	4442.510	+0.295	19.9
Ti 34.4758	4443.976	$\pm 0.000$	.....	4443.976	.....	.....
S 34.5112	4444.307	.....	$\pm 0.000$	4443.976	+0.331	22.3
S 34.9280	4448.217	.....	-0.006	4447.892	+0.319	21.5
Ti 35.0452	4449.320	-0.007	.....	4449.313	.....	.....
Ti 35.9282	4457.613	-0.013	.....	4457.600	.....	.....
S 36.2514	4460.779	.....	-0.009	4460.460	+0.310	20.8
Ti 37.0699	Standard	$\pm 0.000$	.....	4468.663	.....	.....
S 37.1045	4468.998	.....	$\pm 0.000$	4468.663	+0.335	22.5
S 37.8768	4476.523	.....	-0.013	4476.214	+0.306	19.8
Ti 38.3700	4481.460	-0.022	.....	4481.438	.....	.....
S 38.5036	4482.690	.....	-0.023	4482.376	+0.291	19.5
Ti 39.8726	4496.348	-0.030	.....	4496.318	.....	.....
S 39.9741	4497.371	.....	+0.024	4497.046	+0.301	20.1
Ti 40.3770	4501.447	-0.002	.....	4501.445	.....	.....
S 40.4046	4501.727	.....	-0.002	4501.422	+0.303	20.2
Ti 41.4987	4512.917	-0.011	.....	4512.906	.....	.....
S 41.7739	4515.750	.....	-0.009	4515.475	+0.266	17.7
Ti 42.8087	4527.492	-0.002	.....	4527.490	.....	.....
S 43.0320	4529.126	.....	-0.004	4528.798	+0.324	21.5
Ti 44.9110	4548.964	-0.026	.....	4548.938	.....	.....
S 44.9286	4549.263	.....	-0.026	4548.938	+0.299	19.7
S 45.4204	4554.409	.....	-0.004	4554.211	+0.284	18.7
Ti 45.5269	Standard	$\pm 0.000$	.....	4555.662	.....	.....

Curvature Cor. +0.0008 mm.

Mean  $V_a$  +20.3 $V_a$  -23.85 $V_d$  -0.13

Reduction to Sun -23.98

Radial Velocity -3.7 km.

$\alpha$  BOÖTIS—A 3731902, September 6, G. M. T. 13<sup>h</sup> 43<sup>m</sup>  
Hour angle W 4<sup>h</sup> 38<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 28

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Wave-Length in Sun	Displacement	Velocity
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.
T <sub>1</sub> 29.1810	Standard	±0.000	.....	4427.266	.....	.....
S 20.2066	4427.580	.....	±0.000	4427.420	+0.160	+10.8
S 29.3129	4428.886	.....	+0.001	4428.711	+0.176	11.9
S 29.8890	4436.008	.....	+0.008	4435.851	+0.165	11.2
S 30.4227	4442.673	.....	+0.014	4442.510	+0.177	11.9
T <sub>1</sub> 30.5252	4443.961	.....	.....	4443.976	.....	.....
S 30.5392	4444.137	.....	+0.015	4443.976	+0.176	11.9
S 30.8512	4448.072	.....	-0.003	4447.892	+0.177	11.9
T <sub>1</sub> 30.9499	4449.322	-0.009	.....	4449.313	.....	.....
T <sub>1</sub> 31.4348	4455.494	-0.009	.....	4455.485	.....	.....
S 31.4904	4456.205	.....	-0.008	4456.030	+0.167	11.2
T <sub>1</sub> 32.2483	Standard	±0.000	.....	4465.975	.....	.....
S 32.3175	4466.874	.....	±0.000	4466.701	+0.173	11.6
S 32.9524	4475.176	.....	+0.005	4475.026	+0.155	10.4
S 33.0439	4476.381	.....	+0.006	4476.214	+0.173	11.6
T <sub>1</sub> 33.4257	4481.430	+0.008	.....	4481.438	.....	.....
S 33.5085	4482.530	.....	+0.009	4482.376	+0.163	10.9
S 34.4310	4494.900	.....	+0.015	4494.738	+0.177	11.8
T <sub>1</sub> 34.5345	4496.302	+0.016	.....	4496.318	.....	.....
S 34.5999	4497.189	.....	+0.013	4497.046	+0.156	10.4
T <sub>1</sub> 34.9126	4501.446	-0.001	+0.013	4501.445	.....	.....
S 34.9224	4501.579	.....	-0.001	4501.422	+0.156	10.4
T <sub>1</sub> 35.7445	4512.895	+0.011	.....	4512.906	.....	.....
S 35.7562	4513.057	.....	+0.011	4512.906	+0.162	10.8
S 35.9421	4515.642	.....	+0.009	4515.475	+0.176	11.7
T <sub>1</sub> 36.7859	Standard	±0.000	.....	4527.490	.....	.....
S 36.8902	4528.968	.....	±0.000	4528.798	+0.170	11.3

Curvature Cor. +0.0005 mm.

Mean  $V_{\alpha}$  +11.3 $V_{\alpha}$  -15.79 $V_d$  - 0.30

Reduction to Sun -16.09

Radial Velocity - 4.8 km.

SUMMARY OF MEASURES OF  $\alpha$  BOÖTIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
B 293	1902, March 12	-3.6	21	.....	..
B 300	March 13	-4.3	18	-5.7	19
A 336	March 26	-5.4	17	.....	..
B 304	April 2	-4.1	18	-3.8	16
B 311	April 3	.....	..	-3.6	15
B 342	May 7	.....	..	-3.6	15
B 371	June 26	-3.7	14	.....	..
A 373	Sept. 6	-4.8	17	.....	..

Mean -4.3 -4.2

Mean of 8 plates -4.2 km.

Mean of all measures -4.3 km.

The results of other observers for this star are as follows:

Vogel and Scheiner	-	-	-	-	-	-7.7
Belopolsky	-	-	-	-	-	-5.7
Keeler (visual)	-	-	-	-	-	-6.8
Newall	-	-	-	-	-	-5.9

PLATES OF STARS OF THE *ORION* TYPE

The detailed measurements on the different plates on the *Orion* stars follow. The stars are arranged in order of right ascension, and the separate plates of the same star in chronological order. The magnitudes of the stars are from the Harvard Photometry, and the spectral classes are according to Miss Maury's classification (*Annals of Harvard College Observatory*, Vol. XXVIII, 1898). The form of tabulation is the same as for the control plates, and all necessary explanations are found in the introductory note to those plates, and in the general discussion of the method of measurement (p. 7).

1.  $\gamma$  PEGASI

(R. A. =  $0^h 8^m$ ; Dec. =  $+14^\circ 38'$ ; Mag. 3.3; Class IVa)

Eight plates of this star have been measured, seven by A., and five by F., with four common to the two observers. As compared with the more recent plates both the stellar and comparison spectra of the earlier plates are distinctly inferior. The spectrum of this star is much better adapted to accurate measurement than that of the average star of the *Orion* type. All of the lines are comparatively narrow, and numerous oxygen and nitrogen lines are present.

 $\gamma$  PEGASI—A 215

1901, September 5, G. M. T.  $21^h 28^m$   
Hour angle W  $2^\circ 22'$

Star strong; comparison fair.

Measured by A.  
Power 21

Mean of Settings	Wave Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 25.3921	Standard	$\pm 0.000$		4338.084			
S 26.4567	4349.438		-0.007	4319.541	-0.110	-7.6	1
Ti 30.5625	4395.237	-0.036		4395.201			
S 34.1140	4437.639		-0.005	4437.718	-0.084	5.7	1
Ti 34.6256	Standard	$\pm 0.000$		4443.976			
Ti 35.0540	4449.327	-0.014		4449.313			
Ti 36.5711	4468.630	$\pm 0.033$		4468.663			
S 36.7924	4471.493		$\pm 0.036$	4471.676	-0.147	9.9	1
S 37.5326	4481.163		$\pm 0.046$	4481.400	-0.191	12.8	1
Ti 37.5510	4481.392	$\pm 0.046$		4481.438			
Ti 42.7055	4552.627	$\pm 0.005$		4552.632			
S 42.7083	4552.668		$\pm 0.005$	4552.750	-0.077	5.1	1
Ti 43.4780	Standard	0.000		4563.989			
S 43.7429	4567.890		$\pm 0.000$	4567.950	-0.060	5.9	1

Curvature Cor.  $+0.0001$  mm.

Weighted mean  $-7.8$

Mean  $-7.8$

$$\begin{array}{r} V_a +11.66 \\ V_d - 0.19 \\ \hline \end{array}$$

Reduction to Sun  $+11.47$   
Radial Velocity  $+3.7$  km.

$\gamma$  PEGASI- A 2181901, September 6, G. M. T. 17<sup>h</sup> 7<sup>m</sup>  
Hour angle E 2<sup>h</sup> 20<sup>m</sup>

Star strong; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 23.8216	Standard	$\pm 0.000$	.....	4338.084	.....	.....	..
S 24.0582	4340.589	.....	-0.002	4340.634	-0.047	-3.2	1
S 28.3715	4388.086	.....	-0.034	4388.100	-0.048	3.3	1
Ti 28.9837	4395.240	-0.039	.....	4395.201	.....	.....	..
S 30.6752	4414.978	.....	-0.037	4415.076	-0.135	9.2	1
Ti 31.7013	4427.301	-0.035	.....	4427.266	.....	.....	..
S 32.5469	4437.641	.....	-0.017	4437.718	-0.094	6.4	2
Ti 33.0591	4443.982	-0.006	.....	4443.976	.....	.....	..
Ti 33.4860	Standard	$\pm 0.000$	.....	4449.313	.....	.....	..
S 35.2302	4471.539	.....	+0.014	4471.676	-0.123	8.2	2
S 35.9751	4481.254	.....	+0.021	4481.400	-0.125	8.4	3
Ti 35.9875	4481.417	+0.021	.....	4481.438	.....	.....	..
Ti 41.9166	Standard	$\pm 0.000$	.....	4563.939	.....	.....	..
S 42.1850	4567.907	.....	$\pm 0.000$	4567.950	-0.049	3.2	2

Curvature Cor. +0.0001 mm.

Weighted mean  $-6.4$ 

$$V_a + 11.29$$

$$V_d + 0.17$$

Reduction to Sun  $+11.46$ Radial velocity  $+5.1$  km. $\gamma$  PEGASI- A 2331901, September 18, G. M. T. 14<sup>h</sup> 50<sup>m</sup>  
Hour angle E 3<sup>h</sup> 22<sup>m</sup>

Star good; comparison fair.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 18.6731	Standard	$\pm 0.000$	.....	4338.084	.....	.....	..
S 18.9045	4340.549	.....	-0.002	4340.634	-0.087	-6.0	1
S 23.1969	4388.083	.....	-0.032	4388.100	-0.049	3.4	1
Ti 23.8163	4395.239	-0.038	.....	4395.201	.....	.....	..
S 25.5017	4415.111	.....	-0.050	4415.076	-0.015	1.0	2
S 25.6718	4417.151	.....	-0.051	4417.121	-0.021	1.4	2
Ti 25.7371	4417.935	-0.051	.....	4417.884	.....	.....	..
S 27.3544	4437.660	.....	-0.010	4437.718	.....	.....	..
Ti 27.8622	4443.974	+0.002	.....	4443.976	0.068	4.6	2
Ti 29.8037	Standard	$\pm 0.000$	.....	4448.963	.....	.....	..
S 30.0261	4471.548	.....	+0.001	4471.676	-0.124	8.3	1
S 30.7733	4481.330	.....	+0.016	4481.400	-0.054	3.6	3
Ti 30.7803	4481.422	+0.016	.....	4481.438	.....	.....	..
Ti 35.9145	4552.542	+0.050	.....	4552.632	.....	.....	..
S 35.9204	4552.627	.....	+0.000	4552.750	-0.033	2.2	2
Ti 36.0889	4563.899	+0.040	.....	4563.939	.....	.....	..
S 36.9529	4567.810	+0.041	+0.040	4567.950	-0.100	6.6	1
Ti 37.2418	Standard	$\pm 0.000$	.....	4572.156	.....	.....	..
Ti 40.1867	4630.687	.....	$\pm 0.000$	4617.452	.....	.....	..
S 41.0140	.....	.....	$\pm 0.000$	4630.703	-0.016	-1.0	2

Curvature Cor. +0.0001 mm.

Weighted mean  $-3.3$ 

$$V_a + 5.71$$

$$V_d + 0.25$$

Reduction to Sun  $+5.96$ Radial Velocity  $+2.7$  km.Mean  $-3.8$

$\gamma$  PEGASUS—A 233Measured by F.  
Power 17

Mean of Settings	Wave Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 29.999	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 30.295	4340.613	.....	-0.001	4340.634	-0.022	-1.5	1
Ti 35.551	4389.987	-0.052	.....	4389.935	.....	.....	.....
S 36.829	4415.102	.....	-0.054	4415.076	-0.028	-1.9	2
S 36.709	4417.175	.....	-0.054	4417.121	0.000	0.0	2
Ti 37.065	4417.938	-0.054	.....	4417.884	.....	.....	.....
Ti 37.839	4427.303	-0.037	.....	4427.266	.....	.....	.....
S 38.684	4437.684	.....	-0.029	4437.718	-0.063	-4.3	2
Ti 39.192	4444.001	-0.025	.....	4443.976	.....	.....	.....
Ti 41.133	4468.680	-0.017	.....	4468.663	.....	.....	.....
S 41.359	4471.609	.....	-0.014	4471.676	-0.081	-5.4	3
Ti 42.110	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 42.102	4481.335	.....	$\pm 0.000$	4481.400	-0.065	-4.4	3
Ti 47.245	4552.592	$\pm 0.040$	.....	4552.632	.....	.....	.....
S 47.252	4552.690	.....	$\pm 0.040$	4552.750	-0.020	-1.3	2
Ti 48.018	4553.930	$\pm 0.009$	.....	4553.939	.....	.....	.....
S 48.284	4567.872	.....	$\pm 0.008$	4567.950	-0.072	-4.7	2
Ti 48.571	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....

Weighted mean  $-3.3$   
 Curvature Cor.  $0.24$

Mean  $-2.9$ 

$V_a + 5.71$   
 $V_d + 0.25$   
 Reduction to Sun  $+5.96$   
 Radial Velocity  $+2.5$  km.

 $\gamma$  PEGASUS—A 2451902, September 26, G. M. T. 14<sup>h</sup> 5<sup>m</sup>  
Hour angle E 3<sup>h</sup> 38<sup>m</sup>

Star fair; comparison strong.

Measured by A  
Power 21

Ti 32.3644	4386.958	$\pm 0.049$	.....	4387.007	.....	.....	.....
S 32.4692	4388.125	.....	$\pm 0.042$	4388.100	$\pm 0.067$	$\pm 4.6$	1
Ti 33.4861	Standard	$\pm 0.000$	.....	4389.935	.....	.....	.....
S 34.7692	4415.061	.....	-0.016	4415.076	-0.031	-2.1	1
S 34.9082	4417.119	.....	-0.018	4417.121	-0.020	-1.4	1
Ti 35.0096	4417.903	-0.019	.....	4417.884	.....	.....	.....
He 39.3113	4471.691	$\pm 0.015$	.....	4471.676	.....	.....	.....
S 39.3137	4471.692	.....	$\pm 0.015$	4471.676	$\pm 0.031$	$\pm 2.1$	1
S 40.0024	4481.476	.....	-0.040	4481.400	$\pm 0.036$	$\pm 2.4$	3
Ti 40.0625	4481.478	-0.040	.....	4481.438	.....	.....	.....
Ti 43.4188	Standard	$\pm 0.000$	.....	4527.490	.....	.....	.....
Ti 45.2104	4552.632	$\pm 0.000$	.....	4552.632	.....	.....	.....
S 45.2104	4552.750	.....	$\pm 0.000$	4552.750	$\pm 0.009$	$\pm 0.6$	2
Ti 45.9822	4563.923	$\pm 0.016$	.....	4563.939	.....	.....	.....
S 46.2587	4568.010	.....	$\pm 0.003$	4567.950	$\pm 0.063$	$\pm 4.1$	2
Ti 46.3883	4572.165	-0.000	.....	4572.156	.....	.....	.....
S 46.7283	4575.002	.....	-0.008	4574.900	$\pm 0.064$	$\pm 6.2$	1
Ti 49.4881	Standard	$\pm 0.000$	.....	4617.452	.....	.....	.....

Curvature Cor.  $+0.0001$  mm.

Weighted mean  $+2.1$   
 $V_a + 1.80$   
 $V_d + 0.27$

Mean  $+2.1$ 

Reduction to Sun  $+2.07$   
 Radial Velocity  $+4.2$  km.

1901, October 16, G. M. T. 12<sup>h</sup> 46<sup>m</sup>  
Hour angle W 2<sup>h</sup> 20<sup>m</sup>

$\gamma$  PEGASI—B 194

Measured by F.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 21.834	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 22.178	4340.812	.....	-0.002	4340.634	+0.176	+12.2	1
<i>S</i> 27.956	4388.406	.....	-0.063	4388.100	+0.243	16.6	3
<i>Ti</i> 28.756	4395.274	-0.073	.....	4395.201			
<i>Ti</i> 29.305	4400.038	-0.100	.....	4399.935			
<i>S</i> 31.052	4415.399	.....	-0.084	4415.076	+0.239	16.2	2
<i>S</i> 31.285	4417.480	.....	-0.082	4417.121	+0.277	18.8	2
<i>Ti</i> 31.340	4417.966	-0.082	.....	4417.884			
<i>Ti</i> 32.384	4427.361	-0.095	.....	4427.266			
<i>S</i> 33.550	4438.004	.....	-0.075	4437.718	+0.211	14.3	3
<i>Ti</i> 34.203	4444.037	-0.061	.....	4443.976			
<i>Ti</i> 36.816	4468.721	-0.058	.....	4468.663			
<i>He</i> 37.118	4471.636	+0.040	.....	4471.676			
<i>S</i> 37.158	4472.018	.....	-0.052	4471.676	+0.290	19.4	4
<i>Ti</i> 38.130	4481.472	-0.034	.....	4481.438			
<i>S</i> 38.142	4481.595	.....	-0.034	4481.400	+0.161	10.8	5
<i>Ti</i> 41.270	Standard	$\pm 0.000$	.....	4512.906			
<i>Ti</i> 42.680	4527.471	+0.019	.....	4527.490			
<i>Ti</i> 45.045	4552.591	+0.041	.....	4552.632			
<i>S</i> 45.077	4552.936	.....	+0.041	4552.750	+0.227	15.0	4
<i>Ti</i> 46.085	4563.911	+0.028	.....	4563.939			
<i>S</i> 46.471	4568.156	.....	+0.034	4567.950	+0.240	15.8	3
<i>Ti</i> 46.829	4572.116	+0.040	.....	4572.156			
<i>S</i> 47.091	4575.026	.....	+0.039	4574.900	+0.200	13.1	2
<i>Ti</i> 48.431	4590.091	+0.035	.....	4590.126			
<i>S</i> 48.532	4591.233	.....	+0.036	4591.066	+0.203	13.3	
<i>S</i> 49.002	4596.602	.....	+0.040	4596.291	+0.351	22.9	3
<i>Ti</i> 50.793	4617.392	+0.060	.....	4617.452			
<i>S</i> 51.926	4630.844	.....	+0.051	4630.703	+0.192	12.1	1
<i>S</i> 53.466	4649.493	.....	+0.038	4649.250	+0.281	18.1	3
<i>Ti</i> 54.044	4656.610	+0.034	.....	4656.644			
<i>S</i> 54.478	4661.990	.....	+0.032	4661.728	+0.294	18.9	4
<i>Ti</i> 54.938	4667.739	+0.029	.....	4667.768			
<i>Ti</i> 56.071	Standard	$\pm 0.000$	.....	4682.088			
<i>He</i> 58.478	4713.414	-0.162	.....	4713.308			
<i>S</i> 58.496	4713.659	.....	-0.162	4713.308	+0.245	15.6	5

Weighted mean +16.30  
Curvature Cor. - 0.27

Mean +15.8

$V_a$  -8.21  
 $V_d$  -0.19

Reduction to Sun - 8.40  
Radial Velocity + 7.6 km.

$\gamma$  PEGASI B 246

1901, November 27, G. M. T. 12<sup>h</sup> 11<sup>m</sup>  
Hour angle E 1<sup>h</sup> 27<sup>m</sup>

Star good ; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 24.2438	Standard	$\pm 0.000$	.....	4387.007			
<i>S</i> 24.4247	4388.571	.....	$\pm 0.000$	4388.100	+0.471	+32.2	2
<i>Ti</i> 26.9971	4411.222	+0.018	.....	4411.240			
<i>S</i> 27.4696	4415.466	.....	+0.016	4415.076	+0.406	27.6	3
<i>Ti</i> 33.1500	4468.669	-0.006	.....	4468.663			
<i>S</i> 33.5051	4472.134	.....	-0.004	4471.676	+0.454	30.4	2
<i>Ti</i> 34.4500	Standard	$\pm 0.000$	.....	4481.438			
<i>S</i> 34.4929	4481.863	.....	$\pm 0.000$	4481.400	+0.463	31.0	2
<i>Ti</i> 41.2867	4552.593	+0.039	.....	4552.632			
<i>S</i> 41.3428	4553.206	.....	+0.039	4552.750	+0.495	32.6	2
<i>Ti</i> 42.3138	4563.903	+0.036	.....	4563.939			
<i>S</i> 42.7187	4568.410	.....	+0.019	4567.950	+0.479	31.4	3
<i>Ti</i> 43.0535	Standard	$\pm 0.000$	.....	4572.156			

Curvature Cor. +0.0008 mm.

Weighted mean +30.7

Mean +30.9

$V_a$  -24.93  
 $V_d$  + 0.12

Reduction to Sun -24.81  
Radial Velocity + 5.9 km.

$\gamma$  PEGASI—B 246Measured by F.  
Power 17

Mean of Spectrae	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 29.961	4367.455	.....	+0.057	4367.012	+0.500	+34.3	1
Ti 30.000	4367.782	+0.057	.....	4367.839	.....	.....	.....
Ti 32.259	Standard	+0.001	.....	4387.007	.....	.....	.....
S 32.440	4388.571	.....	-0.001	4388.100	+0.470	32.1	2
S 35.489	4415.497	.....	-0.042	4415.076	+0.379	25.7	3
Ti 35.759	4417.934	-0.050	.....	4417.884	.....	.....	.....
Ti 37.534	4434.182	-0.014	.....	4434.168	.....	.....	.....
S 37.972	4438.251	.....	-0.029	4437.718	+0.504	34.1	2
Ti 38.219	4440.551	-0.036	.....	4440.515	.....	.....	.....
Ti 40.892	4465.998	-0.023	.....	4465.975	.....	.....	.....
Ti 41.451	4471.439	-0.031	.....	4471.408	.....	.....	.....
S 41.532	4472.231	.....	-0.019	4471.676	+0.536	35.9	2
Ti 42.467	Standard	+0.001	.....	4481.438	.....	.....	.....
S 42.514	4481.902	.....	+0.001	4481.400	+0.503	33.7	3
Ti 49.306	4552.612	+0.020	.....	4552.632	.....	.....	.....
S 49.392	4553.241	.....	+0.017	4552.750	+0.491	32.3	2
Ti 49.584	4555.656	+0.005	.....	4555.662	.....	.....	.....
Ti 52.654	Standard	+0.001	.....	4590.126	.....	.....	.....
S 52.789	4591.682	.....	$\pm 0.000$	4591.066	+0.616	40.2	1

Weighted mean

+32.6

Mean +33.5

Curvature Cor.

-0.90

 $V_a - 24.93$  $V_d + 0.12$ 

Reduction to Sun

-24.81

Radial Velocity

+ 6.9 km.

 $\gamma$  PEGASI—B 3951902, August 22, G. M. T. 20<sup>h</sup> 40<sup>m</sup>  
Hour angle W 0° 40"

Star good; comparison good.

Measured by A.  
Power 17

S 25.3176	4387.943	.....	$\pm 0.000$	4388.100	-0.157	-10.7	1
Ti 26.1587	Standard	$\pm 0.000$	.....	4395.201	.....	.....	.....
S 28.3946	4414.893	.....	-0.024	4415.076	-0.207	14.2	2
S 28.6322	4417.002	.....	-0.027	4417.121	-0.146	9.9	1
Ti 28.7316	4417.912	-0.028	.....	4417.884	.....	.....	.....
Ti 29.7690	4427.301	-0.035	.....	4427.266	.....	.....	.....
S 30.8040	4437.613	.....	-0.002	4437.718	-0.107	7.2	1
Ti 31.5778	4443.964	+0.012	.....	4443.976	.....	.....	.....
Ti 34.1776	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 34.4670	4471.468	.....	+0.003	4471.676	-0.205	13.8	2
S 35.4614	4481.192	.....	+0.015	4481.400	-0.193	12.9	3
Ti 35.4840	4481.423	+0.015	.....	4481.438	.....	.....	.....
S 42.3591	4552.596	.....	+0.013	4552.750	-0.171	11.3	3
Ti 42.3680	4552.619	+0.013	.....	4552.632	.....	.....	.....
Ti 43.7877	4563.942	-0.003	.....	4563.939	.....	.....	.....
S 43.7499	4567.846	.....	-0.002	4567.950	-0.106	7.0	2
Ti 44.1371	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....
S 44.3220	4574.682	.....	$\pm 0.000$	4574.900	-0.218	14.3	2

Curvature Cor. +0.0009 mm.

Weighted mean

-11.6

Mean -11.2

 $V_a + 17.60$  $V_d - 0.06$ 

Reduction to Sun

+17.54

Radial Velocity

+ 5.9 km.

$\gamma$  PEGASI—B 395Measured by F.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 30.0036	4338.093	-0.009	.....	4338.084			
<i>S</i> 30.2982	4340.438	.....	-0.006	4340.634	-0.202	-14.0	2
<i>Cr</i> 30.8273	Standard	$\pm 0.000$	.....	4344.670			
<i>Cr</i> 34.0985	4371.478	-0.036	.....	4371.442			
<i>S</i> 36.0509	4388.025	.....	-0.038	4388.100	-0.113	7.7	3
<i>Ti</i> 36.8869	4385.240	-0.039	.....	4385.201			
<i>S</i> 39.1255	4414.957	.....	-0.059	4415.076	-0.178	12.1	2
<i>Ti</i> 39.4590	4417.945	-0.061	.....	4417.884			
<i>Ti</i> 40.4960	4427.321	-0.055	.....	4427.266			
<i>S</i> 41.6236	4437.667	.....	-0.049	4437.718	-0.100	6.8	3
<i>Ti</i> 42.3077	4444.021	-0.045	.....	4443.976			
<i>Ti</i> 44.9038	4468.682	-0.019	.....	4468.663			
<i>S</i> 45.1978	4471.531	.....	-0.015	4471.676	-0.160	10.7	3
<i>S</i> 46.1916	4481.246	.....	$\pm 0.000$	4481.400	-0.154	10.3	4
<i>Ti</i> 46.2109	Standard	$\pm 0.000$	.....	4481.438			
<i>S</i> 53.0861	4552.573	.....	+0.007	4552.750	-0.170	11.2	3
<i>Ti</i> 53.0909	4552.625	+0.007	.....	4552.632			
<i>Ti</i> 53.3687	4555.651	+0.011	.....	4555.662			
<i>Ti</i> 54.1247	4563.949	-0.010	.....	4563.939			
<i>S</i> 54.4745	4567.820	.....	$\pm 0.000$	4567.950	-0.130	8.5	3
<i>Ti</i> 54.8641	Standard	$\pm 0.000$	.....	4572.156			
<i>S</i> 55.0962	4574.750	.....	$\pm 0.000$	4574.900	-0.150	9.8	2

Weighted mean — 9.9  
Curvature Cor. — 0.82

Mean —10.1

 $V_{\alpha} +17.60$  $V_d - 0.06$ 

Reduction to Sun —17.54

Radial Velocity + 6.8 km.

1902, October 9, G. M. T. 17<sup>h</sup> 53<sup>m</sup>  
Hour angle W. 1<sup>h</sup> 5<sup>m</sup>

 $\gamma$  PEGASI—B 419

Star good; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 22.0428	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 22.3850	4340.812	.....	-0.001	4340.634	+0.177	+12.2	1
<i>S</i> 28.1141	4388.306	.....	-0.014	4388.100	+0.192	13.1	1
<i>Ti</i> 28.9134	4395.217	-0.016	.....	4395.201			
<i>Ti</i> 29.4541	4399.935	$\pm 0.000$	.....	4399.935			
<i>S</i> 31.1782	4415.206	.....	-0.006	4415.076	+0.124	8.4	2
<i>S</i> 31.4124	4417.308	.....	-0.007	4417.121	+0.180	12.2	1
<i>Ti</i> 31.4773	4417.891	-0.007	.....	4417.884			
<i>Ti</i> 32.5113	4427.258	+0.008	.....	4427.266			
<i>S</i> 33.6671	4437.885	.....	+0.003	4437.718	+0.170	11.5	2
<i>Ti</i> 34.3214	Standard	$\pm 0.000$	.....	4443.976			
<i>Ti</i> 36.9141	4468.657	+0.006	.....	4468.663			
<i>S</i> 37.2371	4471.795	.....	+0.012	4471.676	+0.131	8.8	3
<i>Ti</i> 38.2175	4481.406	+0.032	.....	4481.438			
<i>S</i> 38.2291	4481.521	.....	+0.032	4481.400	+0.153	10.2	5
<i>Ti</i> 45.0835	4552.625	+0.007	.....	4552.632			
<i>S</i> 45.1120	4552.935	.....	+0.007	4552.750	+0.192	12.6	2
<i>Ti</i> 46.1136	Standard	$\pm 0.000$	.....	4563.939			
<i>S</i> 46.4929	4568.149	.....	-0.008	4567.950	+0.191	12.5	4
<i>Ti</i> 46.8533	4572.172	-0.016	.....	4572.156			

Curvature Cor. +0.0008 mm.

Weighted mean +11.0

Mean +11.3

 $V_{\alpha} - 4.63$  $V_d - 0.09$ 

Reduction to Sun — 4.72

Radial Velocity + 6.3 km.

$\gamma$  PEGASI—B 419Measured by F.  
Power 17

Mean of Settings	Wave-length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 29.9510	4387.035	-0.028	.....	4387.007	.....	.....	.....
S 30.0260	4388.309	.....	-0.025	4388.100	+0.184	+12.6	1
Ti 30.8962	4395.207	-0.006	.....	4395.201	.....	.....	.....
Ti 31.4378	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
S 33.1676	4415.266	.....	-0.003	4415.076	+0.187	12.7	2
Ti 33.4584	4417.878	+0.006	.....	4417.884	.....	.....	.....
Ti 34.4958	4427.279	-0.013	.....	4427.266	.....	.....	.....
S 35.6534	4437.925	.....	-0.004	4437.718	+0.203	13.7	1½
Ti 36.3037	4443.980	-0.004	.....	4443.976	.....	.....	.....
Ti 38.8970	4468.667	-0.004	.....	4468.663	.....	.....	.....
Ti 39.1795	4471.410	-0.002	.....	4471.408	.....	.....	.....
S 39.2222	4471.825	.....	-0.002	4471.676	+0.147	9.9	2½
Ti 40.2620	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 40.2149	4481.556	.....	$\pm 0.000$	4481.400	+0.156	10.4	3
Ti 47.0704	4552.625	+0.007	.....	4552.632	.....	.....	.....
S 47.0981	4552.926	.....	+0.007	4552.750	+0.183	12.0	2
Ti 48.1009	4563.931	+0.008	.....	4563.939	.....	.....	.....
S 48.4826	4568.163	.....	+0.004	4567.950	+0.217	14.2	2
Ti 48.8468	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....
S 49.1044	4575.108	.....	+0.001	4574.900	+0.209	13.7	1
Ti 50.4284	4590.113	+0.013	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean +12.0

Mean +12.4

 $V_a$  -4.63 $V_d$  -0.09

Reduction to Sun - 4.72

Radial Velocity + 7.3 km.

SUMMARY OF MEASURES OF  $\gamma$  PEGASI

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 215	1901, Sept. 5	+3.7	6	.....	..
A 218	Sept. 6	+5.1	7	.....	..
A 233	Sept. 18	+2.7	10	+2.5	8
A 245	Sept. 26	+4.2	8	.....	..
B 194	Oct. 16	.....	.....	+7.6	16
B 246	Nov. 27	+5.9	6	+6.9	8
B 335	1902, Aug. 22	+5.9	9	+6.8	9
B 419	Oct. 9	+6.3	9	+7.3	8

Mean +4.8 +6.2

Mean of 8 plates +5.3 km.

Mean of all measures +5.4 km.

2.  $\zeta$  CASSIOPEIAE(R. A.  $0^h 31^m$ ; Dec.  $+53^\circ 21'$ ; Mag. 3.7; Class IVa)

Four plates of this star have been measured, with two common to the two observers. The spectrum has much the same lines as in the case of  $\gamma$  Pegasi, but the lines are considerably broader, and accurate measurement is consequently more difficult.

## ♄ CASSIOPEIAE—A 281

1901, October 31, G. M. T. 13<sup>h</sup> 50<sup>m</sup>  
Hour angle E 0° 20"

Star fair; comparison fair.

Measured by E.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 29.4825	4338.046	+0.038	.....	4338.084	.....	.....	.....
S 29.7341	4340.725	.....	+0.038	4340.634	+0.129	+8.9	1
Ti 30.0789	4344.414	+0.037	.....	4344.451	.....	.....	.....
S 32.1530	4367.070	.....	+0.001	4367.012	+0.059	+4.0	1½
Ti 32.2221	Standard	±0.000	.....	4367.839	.....	.....	.....
Ti 33.9222	4387.046	-0.039	.....	4387.007	.....	.....	.....
He 34.0167	4388.131	-0.031	.....	4388.100	.....	.....	.....
S 34.0234	4388.208	.....	-0.036	4388.100	+0.072	+4.9	2
Ti 35.4240	4404.496	0.063	.....	4404.433	.....	.....	.....
S 36.3179	4415.105	.....	-0.072	4415.076	-0.043	-2.9	2
Ti 36.5559	4417.958	-0.074	.....	4417.884	.....	.....	.....
Ti 37.8895	4434.174	-0.006	.....	4434.168	.....	.....	.....
S 38.1825	4437.790	.....	+0.001	4437.718	+0.073	+4.9	1½
Ti 38.4019	4440.510	+0.005	.....	4440.515	.....	.....	.....
Ti 40.4150	4465.983	-0.008	.....	4465.975	.....	.....	.....
S 40.8538	4471.663	.....	-0.005	4471.676	-0.018	-1.2	3
Ti 41.6007	Standard	±0.000	.....	4481.438	.....	.....	.....
S 41.6002	4481.431	.....	±0.000	4481.400	+0.031	+2.1	4
Ti 46.7395	4552.599	+0.033	.....	4552.632	.....	.....	.....
S 46.7538	4552.807	.....	+0.033	4552.750	+0.090	+5.9	2
Ti 46.9467	4555.620	+0.042	.....	4555.662	.....	.....	.....
Ti 47.5099	4563.894	+0.045	.....	4563.939	.....	.....	.....
S 47.7895	4568.036	.....	+0.038	4567.950	+0.124	+8.1	1
Ti 49.2547	Standard	±0.000	.....	4590.126	.....	.....	.....
Ti 51.7687	Standard	±0.000	.....	4629.521	.....	.....	.....
S 51.8431	4630.717	.....	±0.000	4630.703	+0.014	+0.9	2
Ti 54.0936	Standard	±0.000	.....	4667.768	.....	.....	.....
Ti 56.5594	Standard	±0.000	.....	4710.368	.....	.....	.....
He 56.7282	4713.365	-0.057	.....	4713.308	.....	.....	.....
S 56.7296	4713.391	.....	-0.028	4713.308	+0.055	+3.5	3

Curvature Cor.+0.0009 mm.

Weighted mean

+2.7

Mean +3.6

$$\begin{aligned} V_a & -1.90 \\ V_d & +0.02 \end{aligned}$$

Reduction to Sun

-1.88

Radial Velocity

+0.8 km.

## ♄ CASSIOPEIAE—B 211

1901, November 7, G. M. T. 14<sup>h</sup> 43<sup>m</sup>  
Hour angle E 0° 43"

Star good; comparison on but one side of star spectrum.

Measured by A.  
Power 21

Ti 19.3141	Standard	±0.000	.....	4338.084	.....	.....	.....
Ti 25.2765	.....	-0.066	.....	4387.007	.....	.....	.....
S 25.4128	4388.268	.....	-0.094	4388.100	+0.074	+5.1	2
S 30.9939	4437.819	.....	-0.010	4437.718	+0.091	6.2	1
Ti 31.6579	Standard	±0.000	.....	4443.976	.....	.....	.....
Ti 34.2861	4468.670	-0.007	.....	4468.663	.....	.....	.....
S 34.5904	4471.803	.....	±0.000	4471.676	+0.127	8.5	3
Ti 35.5771	4481.413	+0.025	.....	4481.438	.....	.....	.....
S 35.5847	4481.497	.....	+0.025	4481.400	+0.122	8.2	2
Ti 42.4790	4552.614	+0.018	.....	4552.632	.....	.....	.....
S 42.5045	4552.890	.....	+0.018	4552.750	+0.158	10.4	2
Ti 43.5160	Standard	±0.000	.....	4563.939	.....	.....	.....
S 43.8931	4568.101	.....	±0.000	4567.750	+0.151	9.9	1
Ti 44.2586	4572.157	-0.001	.....	4572.156	.....	.....	.....
S 44.5133	4574.996	.....	-0.001	4574.900	+0.095	6.2	1

Curvature Cor. +0.0002 mm.

Weighted mean

+9.7

Mean +7.8

$$\begin{aligned} V_a & -4.48 \\ V_d & +0.04 \end{aligned}$$

Reduction to Sun

-4.44

Radial Velocity

+3.5 km.

1901. November 27, G. M. T. 16<sup>h</sup> 48<sup>m</sup>  
Hour angle W 2° 43'

ζ CASSIOPEIAE B 248

Star good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Lengths by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 25.8586	Standard	± 0.000	.....	4387.007	.....	.....	.....
S 25.0051	4388.274	.....	+0.002	4388.100	+0.176	+12.0	3
Ti 28.6093	4411.207	+0.033	.....	4411.240	.....	.....	.....
S 29.2890	4417.324	.....	+0.021	4417.121	+0.224	15.2	1
Ti 31.1310	4434.181	-0.013	.....	4434.168	.....	.....	.....
S 31.5429	4438.000	.....	± 0.000	4437.718	+0.282	19.1	3
Ti 32.1785	4443.956	+0.020	.....	4443.976	.....	.....	.....
Ti 34.7653	4468.700	-0.037	.....	4468.663	.....	.....	.....
S 35.0671	4471.938	.....	-0.028	4471.676	+0.234	15.7	2
Ti 36.0618	Standard	± 0.000	.....	4481.438	.....	.....	.....
S 36.0736	4481.555	.....	± 0.000	4481.400	+0.155	10.4	3
Ti 42.8983	4552.605	+0.027	.....	4552.632	.....	.....	.....
S 42.9342	4552.998	.....	+0.027	4552.750	+0.275	18.1	2
Ti 43.9288	4563.956	-0.017	.....	4563.939	.....	.....	.....
S 44.3155	4568.259	.....	-0.013	4567.950	+0.296	19.4	1
S 44.9318	4575.170	.....	-0.010	4574.900	+0.260	17.0	1
Ti 46.2466	Standard	± 0.000	.....	4590.126	.....	.....	.....
S 46.8046	4596.563	.....	± 0.000	4596.291	+0.272	17.8	2

Curvature Cor. +0.0009 mm.

Weighted mean +15.5

Mean +16.1

$$\begin{aligned} V_a &= 11.41 \\ V_d &= 0.14 \end{aligned}$$

Reduction to Sun 11.55

Radial Velocity + 4.0 km.

ζ CASSIOPEIAE B 248

Measured by F.  
Power 12

Ti 34.9000	4340.689	.....	+0.108	4340.634	+0.163	+11.3	2
S 34.9075	4341.425	+0.105	.....	4341.530	.....	.....	.....
Ti 40.4650	Standard	± 0.000	.....	4387.007	.....	.....	.....
S 40.6127	4388.284	.....	+0.005	4388.100	+0.189	12.9	3
Ti 42.4605	4404.465	+0.032	.....	4404.433	.....	.....	.....
S 43.6905	4415.187	.....	+0.027	4415.076	+0.138	9.4	1
Ti 45.7405	4434.184	+0.016	.....	4434.168	.....	.....	.....
S 46.1508	4437.994	.....	+0.010	4437.718	+0.286	19.3	1
Ti 49.0585	4466.007	-0.032	.....	4465.975	.....	.....	.....
S 49.7048	4471.911	.....	-0.022	4471.676	+0.213	14.3	3
Ti 50.6725	Standard	± 0.000	.....	4481.438	.....	.....	.....
S 50.6848	4481.560	.....	± 0.000	4481.400	+0.160	10.7	1
Ti 57.5090	4552.602	+0.030	.....	4552.632	.....	.....	.....
S 57.5480	4553.028	.....	+0.030	4552.750	+0.308	20.3	3
S 58.7222	4568.228	.....	+0.017	4567.950	+0.195	12.8	2
Ti 60.8270	Standard	± 0.000	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0015 mm.

Weighted mean +13.9

Mean +13.9

$$\begin{aligned} V_a &= 11.41 \\ V_d &= 0.14 \end{aligned}$$

Reduction to Sun 11.55

Radial Velocity + 2.4 km.

1902, July 22, G. M. T. 19<sup>h</sup> 10<sup>m</sup>Hour angle E 3<sup>h</sup> 10<sup>m</sup>

## § CASSIOPEIAE—A 355

Star good; comparison imperfect.

Measured by A.

Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 24.1893	Standard	±0.000	.....	4338.084	.....	.....	.....
<i>S</i> 24.4017	4340.360	.....	-0.001	4340.634	-0.275	-19.5	3
<i>S</i> 28.6706	4387.926	.....	-0.023	4388.100	-0.197	13.5	2
<i>Ti</i> 29.7021	4399.963	-0.028	.....	4399.935	.....	.....	.....
<i>Ti</i> 31.9750	4427.286	-0.020	.....	4427.266	.....	.....	.....
<i>Ti</i> 33.3186	Standard	±0.000	.....	4443.976	.....	.....	.....
<i>Ti</i> 35.2474	4468.672	-0.009	.....	4468.663	.....	.....	.....
<i>S</i> 35.4537	4471.366	.....	-0.003	4471.676	-0.316	21.2	1
<i>S</i> 36.1905	4481.075	.....	+0.019	4481.400	-0.306	20.5	2
<i>Ti</i> 36.2164	4481.419	+0.019	.....	4481.438	.....	.....	.....
<i>S</i> 41.3134	4552.521	.....	+0.012	4552.750	-0.217	14.3	2
<i>Ti</i> 41.3201	4552.620	+0.012	.....	4552.632	.....	.....	.....
<i>Ti</i> 42.0857	4563.929	+0.010	.....	4563.939	.....	.....	.....
<i>S</i> 42.3338	4567.631	.....	+0.005	4567.950	-0.314	20.6	2
<i>Ti</i> 42.6353	Standard	±0.000	.....	4572.156	.....	.....	.....
<i>S</i> 42.7960	4574.579	.....	±0.000	4574.900	-0.311	20.4	1

Curvature Cor. +0.0005 mm.

Weighted mean

-18.1

Mean -18.5

 $V_a + 20.77$  $V_d + 0.15$ 

Reduction to Sun

+20.92

Radial Velocity

+ 2.8 km.

## § CASSIOPEIAE—A 355

Measured by F.

Power 12

<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>	<i>Ti</i>	<i>S</i>
28.9627	29.1747	33.3655	33.4441	34.0764	36.7481	37.5660	38.0936	40.0224	40.2310	40.9630	40.9873	46.0922	46.0908	46.8620	47.1174	47.4106	47.5781		
Standard	4340.356	4387.004	4387.912	4395.263	4427.258	4437.367	4443.970	Standard	4471.387	4481.032	4481.355	4552.570	4552.638	4563.943	4567.755	Standard	4574.682		
±0.000	.....	+0.003	.....	-0.062	+0.008	.....	±0.006	±0.000	.....	+0.018	.....	.....	+0.024	-0.004	-0.002	±0.000	.....	.....	.....
.....	0.000	.....	-0.005	.....	.....	+0.007	.....	.....	+0.018	+0.083	.....	.....	.....	.....	.....	.....	+0.002	.....	.....
.....	4340.634	.....	4388.100	.....	4427.266	4437.718	4443.976	.....	4471.676	4481.400	4481.438	4552.750	4552.662	4563.939	4567.950	4572.156	4574.900	.....	.....
.....	-0.279	.....	-0.193	.....	.....	-0.344	.....	.....	-0.271	-0.285	.....	.....	-0.156	.....	-0.197	-0.216	.....	.....	.....
.....	-19.3	.....	13.2	.....	.....	23.2	.....	.....	18.2	19.1	.....	.....	10.3	.....	12.9	14.2	.....	.....	.....
.....	2	.....	2	.....	.....	2	.....	.....	2	1	.....	.....	1½	.....	1	1½	.....	.....	.....

Curvature Cor. +0.0010 mm.

Weighted mean

-16.9

Mean -16.3

 $V_a + 20.77$  $V_d + 0.15$ 

Reduction to Sun

+20.19

Radial Velocity

+ 4.0 km.

## SUMMARY OF MEASURES OF § CASSIOPEIAE

Plate	Date	Adams	No. of lines	Frost	No. of lines
A 281	1901, Oct. 31	.....	.....	+0.8	11
B 211	Nov. 7	+3.5	7	.....	.....
B 248	Nov. 27	+4.0	9	2.4	8
A 355	1902, July 22	+2.8	7	+4.0	7

Mean +3.3

+2.4

Mean of 4 plates +2.7 km.

Mean of all measures +2.9 km.

3.  $\epsilon$  CASSIOPEIAE(R. A. =  $1^h 47^m$ ; Dec. =  $+63^\circ 11'$ ; Mag. 3.6; Class IV *ab*)

Four plates of this star have been measured, all of which are common to the two observers. The spectrum contains but few lines, and these are very broad and difficult of measurement.

 $\epsilon$  CASSIOPEIAE—A 2611901, October 3, G. M. T.  $17^h 15^m$ Hour angle E  $1^\circ 35'$ 

Star fair; comparison good.

Measured by A.

Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
t. m.	t. m.	t. m.	t. m.	t. m.	t. m.	km	
Ti 19.1034	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 19.3331	.....	.....	-0.001	4340.634	-0.362	-25.0	1
S 23.6055	.....	.....	-0.014	4388.100	-0.294	20.1	1
Ti 24.2470	.....	-0.017	.....	4395.201	.....	.....	.....
Ti 26.9383	Standard	$\pm 0.000$	.....	4427.266	.....	.....	.....
S 27.7635	.....	.....	+0.009	4437.718	-0.299	20.2	1
Ti 28.2905	.....	+0.014	.....	4443.976	.....	.....	.....
Ti 30.2297	.....	+0.018	.....	4468.663	.....	.....	.....
S 34.4385	.....	.....	+0.016	4471.676	-0.303	20.3	1
S 31.1840	.....	.....	+0.011	4481.400	-0.264	17.7	1
Ti 32.7017	Standard	$\pm 0.000$	.....	4501.445	.....	.....	.....

Curvature Cor. +0.0001mm.

Weighted mean

-20.7

Mean -20.7

 $V_a + 13.49$  $V_d + 0.06$ 

Reduction to Sun

+13.55

Radial Velocity

-7.1 km.

 $\epsilon$  CASSIOPEIAE—A 261

Measured by F.

Power 12

Ti 30.7668	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 30.9890	.....	.....	-0.002	4340.634	-0.184	-12.7	2
S 35.2729	.....	.....	-0.070	4388.100	-0.273	18.7	1
Ti 35.9119	.....	-0.080	.....	4395.201	.....	.....	.....
Ti 36.3172	.....	-0.073	.....	4399.535	.....	.....	.....
Ti 41.8970	.....	-0.048	.....	4468.663	.....	.....	.....
S 42.1104	.....	.....	-0.036	4471.676	-0.231	15.5	2
Ti 42.8707	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 42.8061	.....	.....	$\pm 0.000$	4481.400	-0.286	19.1	2
Ti 48.7767	.....	+0.019	.....	4563.939	.....	.....	.....
Ti 49.3307	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....

Curvature Cor. +0.0003 mm.

Weighted mean

-16.2

Mean -16.5

 $V_a + 13.49$  $V_d + 0.06$ 

Reduction to Sun

+13.55

Radial Velocity

-2.6 km.

$\epsilon$  CASSIOPEIAE—A 2751901, October 23, G. M. T. 20<sup>h</sup> 35<sup>m</sup>  
Hour angle W 3<sup>h</sup> 5<sup>m</sup>

Star rather weak; comparison good.

Measured by A.  
Power 21

Mean of Settings		Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.		t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i>	24.5055	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i>	29.0245	4387.844	.....	$\pm 0.000$	4388.100	-0.256	-17.5	2
<i>Ti</i>	30.0703	Standard	$\pm 0.000$	.....	4399.935			
<i>Ti</i>	32.9639	4427.263	$\pm 0.003$	.....	4427.266			
<i>S</i>	33.2000	4437.514	.....	$\pm 0.025$	4437.718	-0.179	12.1	2
<i>Ti</i>	34.1426	4449.261	$\pm 0.052$	.....	4449.313			
<i>Ti</i>	35.6617	4468.633	$\pm 0.030$	.....	4468.663			
<i>S</i>	35.8816	4471.484	.....	$\pm 0.023$	4471.676	-0.169	11.3	4
<i>S</i>	36.6239	4481.194	.....	$\pm 0.000$	4481.400	-0.206	13.9	3
<i>Ti</i>	36.6424	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor.  $+0.0002$  mm.

Weighted mean

13.3

Mean  $-13.7$  $V_a +7.65$  $V_d -0.11$ Reduction to Sun  $+7.54$ Radial Velocity  $-5.8$  km. $\epsilon$  CASSIOPEIAE—A 275Measured by F.  
Power 12

<i>Ti</i>	30.7013	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i>	30.9194	4340.398	.....	$\pm 0.000$	4340.634	-0.236	-16.3	$2\frac{1}{2}$
<i>S</i>	35.2210	4387.871	.....	$\pm 0.008$	4388.100	-0.221	15.1	
<i>Ti</i>	35.8565	4395.195	$\pm 0.009$	.....	4395.201			
<i>Ti</i>	36.2644	Standard	$\pm 0.000$	.....	4399.935			
<i>Ti</i>	41.8583	4468.647	$\pm 0.016$	.....	4468.663			
<i>S</i>	42.0745	4471.448	.....	$\pm 0.012$	4471.676	-0.216	14.5	2
<i>S</i>	42.8145	4481.122	.....	$\pm 0.000$	4481.400	-0.278	18.6	2
<i>Ti</i>	42.8385	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor.  $+0.0003$  mm.

Weighted mean

 $-16.0$ Mean  $-16.1$  $V_a +7.65$  $V_d -0.11$ Reduction to Sun  $+7.54$ Radial Velocity  $-8.5$  km. $\epsilon$  CASSIOPEIAE—A 2781901, October 25, G. M. T. 14<sup>h</sup> 8<sup>m</sup>  
Hour angle E 3<sup>h</sup> 35<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 25

<i>S</i>	23.7063	4387.867	.....	$-0.017$	4388.100	$-0.250$	$-17.1$	1
<i>Ti</i>	24.3426	4395.218	$-0.017$	.....	4395.201			
<i>Ti</i>	24.7471	Standard	$\pm 0.000$	.....	4399.935			
<i>Ti</i>	26.2616	4417.899	$-0.015$	.....	4417.884			
<i>S</i>	27.8617	4437.417	.....	$-0.003$	4437.718	$-0.304$	20.5	1
<i>Ti</i>	28.3891	Standard	$\pm 0.000$	.....	4443.976			
<i>Ti</i>	30.3307	4468.678	$-0.015$	.....	4468.663			
<i>S</i>	30.5491	4471.513	.....	$-0.012$	4471.676	$-0.175$	11.7	3
<i>S</i>	31.2868	4481.174	.....	$\pm 0.000$	4481.400	$-0.226$	15.1	4
<i>Ti</i>	31.3068	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor.  $+0.0002$  mm

Weighted mean

 $-14.8$ Mean  $-16.1$  $V_a +7.09$  $V_d +0.12$ Reduction to Sun  $+7.21$ Radial Velocity  $-7.6$  km.

$\epsilon$  CASSIOPEIAE - A 278Measured by F.  
Power 12

Mean of Settings	Wave-length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 29.3007	Standard	$\pm 0.000$		4338.084			
S 29.3350	4340.574		$\pm 0.000$	4340.634	-0.060	-4.1	1
Ti 33.7369	4387.004	+0.003		4387.007			
S 33.8060	4387.797		+0.003	4388.100	-0.300	20.5	2
Ti 34.8535	Standard	$\pm 0.000$		4389.935			
Ti 40.4379	4468.675	-0.012		4468.683			
S 40.6815	4471.579		-0.009	4471.676	-0.106	7.1	2
S 41.3359	4481.204		$\pm 0.000$	4481.400	-0.196	13.1	2
Ti 41.4136	Standard	$\pm 0.000$		4481.438			

Curvature Cor.  $-0.0003$  mm.

Weighted Mean  $-12.2$   
 $V_a + 7.09$   
 $V_d + 0.12$   
 Reduction to Sun  $+ 7.21$   
 Radial Velocity  $- 5.0$  km.

Mean  $-11.2$  $\epsilon$  CASSIOPEIAE—B 3991902, August 27, G. M. T. 18<sup>h</sup> 49<sup>m</sup>  
Hour angle E 2<sup>h</sup> 21<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 15

Ti 20.8692	Standard	$\pm 0.000$		4338.084			
S 21.1412	4340.314		+0.002	4340.634	-0.318	-22.0	1
S 26.8703	4387.657		+0.044	4388.100	-0.399	27.3	1
Ti 27.7456	4395.150	+0.051		4395.201			
Ti 28.2855	Standard	$\pm 0.000$		4399.935			
Ti 33.7409	4449.296	+0.017		4449.313			
Ti 35.7701	4468.661	+0.002		4468.683			
S 36.0427	4471.304		+0.002	4471.676	-0.370	24.8	2
S 37.0402	4481.066		$\pm 0.000$	4481.400	-0.334	22.4	2
Ti 37.0779	Standard	$\pm 0.000$		4481.438			

Curvature Cor.  $+0.0008$  mm.

Weighted mean  $-23.9$   
 $V_a + 19.50$   
 $V_d + 0.09$   
 Reduction to Sun  $+19.59$   
 Radial Velocity  $- 4.3$  km.

Mean  $-24.1$  $\epsilon$  CASSIOPEIAE—B 399Measured by F.  
Power 12

Ti 32.8466	Standard	$\pm 0.000$		4468.683			
S 33.1104	4471.282		$\pm 0.000$	4471.676	-0.394	-26.4	2
S 34.1070	4481.030		$\pm 0.000$	4481.400	-0.370	24.8	2
Ti 34.1485	Standard	$\pm 0.000$		4481.438			
Ti 34.8623	Standard	$\pm 0.000$		4489.493			

Curvature Cor.  $+0.0012$  mm.

Weighted mean  $-25.6$   
 $V_a + 19.50$   
 $V_d + 0.09$   
 Reduction to Sun  $+19.59$   
 Radial Velocity  $- 6.0$  km.

Mean  $-25.6$

SUMMARY OF MEASURES OF  $\epsilon$  CASSIOPEIAE

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 261	1901, Oct. 3	-7.1	5	-2.6	4
A 275	Oct. 23	-5.8	4	-8.5	4
A 278	Oct. 25	-7.6	4	-5.0	4
B 399	1902, Aug. 27	-4.3	4	-6.0	2

Mean -6.2 -5.5

Mean of 4 plates -5.9 km.

Mean of all measures -5.9 km.

4.  $\zeta$  PERSEI(R. A. =  $3^h 48^m$ ; Dec. =  $+31^\circ 35'$ ; Mag. 3.1; Class IIIa)

Five plates of this star have been measured, five by A., and two by F. The lines in this spectrum, though numerous, are extremely broad and ill defined, making accurate measurement difficult.

1901, September 12, G. M. T.  $18^h 4^m$   
Hour angle E  $4^h 6^m$

$\zeta$  PERSEI — A 226  
Star rather weak; comparison fair.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>S</i> 21.8256	4387.976	.....	+0.033	4388.100	-0.091	-6.2	1
<i>He</i> 24.8336	4388.067	+0.033	.....	4388.100			
<i>Ti</i> 25.4507	Standard	$\pm 0.000$	.....	4385.201			
<i>S</i> 32.4118	4481.336	.....	-0.001	4481.400	-0.065	4.4	1
<i>Ti</i> 32.4196	4481.439	-0.001	.....	4481.438			
<i>Ti</i> 37.3068	Standard	$\pm 0.000$	.....	4548.938			
<i>Ti</i> 38.3552	4563.915	+0.024	.....	4563.939			
<i>S</i> 38.6014	4567.852	.....	+0.018	4567.950	-0.080	5.2	3
<i>Ti</i> 38.8901	4572.146	+0.010	.....	4572.156			
<i>S</i> 39.0692	4574.822	.....	+0.010	4574.900	-0.068	4.5	1
<i>Ti</i> 41.8387	4617.445	+0.007	.....	4617.452			
<i>S</i> 43.9076	4650.888	.....	+0.002	4650.925	-0.035	2.3	1
<i>S</i> 44.5498	4661.564	.....	+0.001	4661.728	-0.163	10.5	1
<i>Ti</i> 44.9191	Standard	$\pm 0.000$	.....	4667.768			
<i>S</i> 47.5475	4713.357	.....	-0.113	4713.308	-0.064	4.1	2
<i>He</i> 47.5511	4713.421	-0.113	.....	4713.308			

Curvature Cor. +0.0001 mm.

Weighted mean - 5.2

Mean -5.3

$$V_a + 27.45$$

$$V_d + 0.26$$

Reduction to Sun +27.72

Radial Velocity +22.5 km.

1901, September 18, G. M. T.  $18^h 26^m$   
Hour angle E  $3^h 28^m$

$\zeta$  PERSEI — A 235  
Star good; comparison good.

Measured by A  
Power 21

<i>S</i> 31.2357	4388.036	.....	$\pm 0.000$	4388.100	-0.064	-4.4	1
<i>Ti</i> 31.8557	Standard	$\pm 0.000$	.....	4385.201			
<i>S</i> 33.5371	4415.034	.....	-0.023	4415.076	-0.065	-4.4	3
<i>S</i> 33.7142	4417.157	.....	-0.025	4417.121	+0.011	+0.8	2
<i>Ti</i> 33.7768	4417.910	-0.026	.....	4417.884			
<i>Ti</i> 37.8433	Standard	$\pm 0.000$	.....	4468.663			
<i>S</i> 38.0673	4471.571	.....	$\pm 0.000$	4471.676	-0.105	-7.0	2
<i>Ti</i> 45.2786	Standard	$\pm 0.000$	.....	4572.156			
<i>S</i> 45.4611	4574.890	.....	$\pm 0.000$	4574.900	-0.010	-0.6	1

Curvature Cor. +0.0002 mm.

Weighted mean - 3.4

Mean -3.1

$$V_a + 26.38$$

$$V_d + 0.23$$

Reduction to Sun +26.61

Radial Velocity +23.2 km.

1901, November 8, G. M. T. 16<sup>h</sup> 33<sup>m</sup>  
Hour angle E 1<sup>h</sup> 55<sup>m</sup>

§ PERSEI - B218

Star fair; comparison fair.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 20.3486	Standard	±0.000	.....	4338.084	.....	.....	.....
S 20.7005	4340.868	.....	+0.002	4340.634	+0.236	+16.3	1
S 21.8100	4349.726	.....	+0.007	4349.541	+0.192	13.2	2
S 23.9597	4367.254	.....	+0.018	4367.012	+0.260	17.8	1
Ti 24.0282	4367.821	+0.018	.....	4367.839	.....	.....	.....
Ti 26.3119	4387.004	+0.003	.....	4387.007	.....	.....	.....
S 26.4615	4388.281	.....	+0.003	4388.100	+0.184	12.6	1
S 29.7918	4417.376	.....	±0.000	4417.121	+0.255	17.3	1
Ti 29.8487	Standard	±0.000	.....	4417.884	.....	.....	.....
Ti 35.3198	4468.676	-0.013	.....	4468.663	.....	.....	.....
S 35.6552	4471.917	.....	-0.013	4471.676	+0.228	15.3	3
Ti 36.6225	4481.450	-0.012	.....	4481.438	.....	.....	.....
Ti 43.5244	4552.612	+0.020	.....	4552.632	.....	.....	.....
S 43.5581	4552.981	.....	+0.020	4552.750	+0.251	16.5	2
Ti 44.5597	Standard	±0.000	.....	4563.939	.....	.....	.....
S 44.9421	4568.167	.....	±0.000	4567.950	+0.217	14.2	1

Curvature Cor. +0.0007 mm.

Weighted mean + 15.3

Mean +15.4

$V_a$  +7.57

$V_d$  +0.14

Reduction to Sun + 7.71

Radial Velocity +23.0 km.

§ PERSEI - B218

Measured by F.  
Power 12

Ti 29.5641	4338.015	+0.069	.....	4338.084	.....	.....	.....
S 29.8943	4340.634	.....	+0.075	4340.634	+0.075	+ 5.2	1
Ti 30.3631	4344.370	+0.081	.....	4344.451	.....	.....	.....
S 33.1907	4367.383	.....	+0.001	4367.012	+0.372	+25.5	1
Ti 33.2455	Standard	±0.000	.....	4367.839	.....	.....	.....
Ti 35.5309	4387.068	-0.061	.....	4387.007	.....	.....	.....
S 35.6642	4388.208	.....	-0.060	4388.100	+0.048	+ 3.3	1 $\frac{1}{2}$
Ti 37.0283	4399.982	-0.047	.....	4399.935	.....	.....	.....
S 38.7463	4415.114	.....	-0.055	4415.076	-0.017	- 1.2	1 $\frac{1}{2}$
Ti 39.0629	4417.940	-0.056	.....	4417.884	.....	.....	.....
Ti 44.2508	4465.012	-0.037	.....	4465.975	.....	.....	.....
Ti 44.8131	4471.429	-0.021	.....	4471.408	.....	.....	.....
S 44.8643	4471.925	.....	-0.020	4471.676	+0.229	+15.4	2
Ti 45.8403	Standard	±0.000	.....	4481.438	.....	.....	.....
Ti 52.7435	4552.588	+0.044	.....	4552.632	.....	.....	.....
S 52.7644	4552.814	.....	+0.043	4552.750	+0.107	+ 7.0	2
Ti 53.0235	4555.626	+0.036	.....	4555.662	.....	.....	.....
Ti 53.7800	4563.897	+0.042	.....	4563.939	.....	.....	.....
S 54.1745	4568.247	.....	+0.026	4567.950	+0.323	+21.2	2
Ti 54.5259	4572.143	+0.013	.....	4572.156	.....	.....	.....
S 54.8032	4575.231	.....	+0.011	4574.900	+0.343	+22.5	1
Ti 56.1242	Standard	±0.000	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted Mean +14.2

Mean +12.4

$V_a$  +7.57

$V_d$  +0.14

Reduction to Sun + 7.71

Radial Velocity +21.9 km.

## § PERSEI—B 232

1901, November 14, G. M. T. 20<sup>h</sup> 9<sup>m</sup>  
Hour angle W 2<sup>h</sup> 12<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 2i

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 20.4179	4387.005	+0.002	.....	4387.007			
S 20.5786	4388.380	.....	+0.002	4388.100	+0.282	+19.3	1
Ti 21.9154	Standard	±0.000	.....	4399.935			
Ti 23.1992	4411.225	+0.015	.....	4411.240			
S 23.6635	4415.355	.....	+0.014	4415.076	+0.293	19.9	1
S 23.8884	4417.365	.....	+0.014	4417.121	+0.258	17.5	1
Ti 29.4079	Standard	±0.000	.....	4468.663			
S 29.7458	4471.931	.....	±0.000	4471.676	+0.255	17.1	1
Ti 37.6141	4552.633	-0.001	.....	4552.632			
S 37.6446	4552.964	.....	-0.001	4552.750	+0.213	14.0	1
Ti 38.6481	Standard	±0.000	.....	4563.939			
S 39.0408	4568.278	.....	-0.022	4567.950	+0.306	20.1	1
Ti 39.3937	4572.199	-0.043	.....	4572.156			
S 39.6564	4575.131	.....	-0.043	4574.900	+0.188	12.3	1

Curvature Cor. +0.0008 mm.

Weighted mean  $V_a + 17.2$   
 $V_d + 4.50$   
 $V_d - 0.16$   
 Reduction to Sun  $+ 4.34$   
 Radial Velocity  $+ 21.5$  km.

Mean +17.2

## § PERSEI—B 232

Measured by F.  
Power 12

Ti 29.6003	Standard	±0.000	.....	4338.084			
S 29.9374	4340.753	.....	-0.002	4340.634	+0.117	+ 8.1	1
Ti 30.0357	4341.533	-0.003	.....	4351.530			
Ti 33.2745	4367.813	+0.026	.....	4367.839			
Ti 35.5550	4386.997	+0.010	.....	4387.007			
S 35.7042	4388.272	.....	+0.010	4388.100	+0.182	12.4	2
Ti 37.5680	4404.420	+0.013	.....	4404.433			
S 38.7827	4415.164	.....	+0.003	4415.076	+0.091	6.2	1½
Ti 39.0870	Standard	±0.000	.....	4417.884			
Ti 44.2955	4465.952	+0.023	.....	4465.975			
Ti 44.8288	4471.393	+0.015	.....	4471.408			
S 44.8784	4471.874	.....	+0.014	4471.676	+0.222	14.8	2
Ti 45.8569	Standard	±0.000	.....	4481.438			
Ti 52.7516	Standard	±0.000	.....	4552.632			
S 52.7963	4553.117	.....	±0.000	4552.750	+0.367	24.2	1
Ti 53.7863	4563.933	+0.006	.....	4563.939			
S 54.1777	4568.246	.....	-0.006	4567.950	+0.307	20.2	1½
Ti 54.5307	4572.171	-0.015	.....	4572.156			
S 54.7863	4575.019	.....	-0.013	4574.900	+0.100	6.9	1
Ti 56.1281	4590.151	-0.025	.....	4590.126			
Ti 59.4987	Standard	±0.000	.....	4629.521			
S 59.6276	4631.067	.....	±0.000	4630.703	+0.364	23.6	1
S 60.5525	4642.246	.....	±0.000	4641.886	+0.360	23.3	1
Ti 60.8086	4645.369	-0.001	.....	4645.368			
Ti 61.7253	4656.651	-0.007	.....	4656.644			
S 62.1632	4662.086	.....	-0.018	4661.728	+0.350	22.5	1
Ti 62.6184	4667.796	-0.028	.....	4667.768			
Ti 65.9195	Standard	±0.000	.....	4710.471			
S 66.1666	4713.646	.....	+0.002	4713.308	+0.340	21.6	1

Curvature Cor. +0.0013 mm.

Weighted mean  $V_a + 16.0$   
 $V_d + 4.50$   
 $V_d - 0.16$   
 Reduction to Sun  $+ 4.34$   
 Radial Velocity  $+ 20.3$  km.

Mean +16.6

1902, October 15, G. M. T. 16<sup>h</sup> 43<sup>m</sup>  
Hour angle E 3° 25<sup>m</sup>

§ PERSEI—B 424

Star good; comparison good.

Measured by A.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 22.2046	Standard	±0.000	.....	4338.084	.....	.....	.....
S 22.5242	4340.628	.....	-0.002	4340.634	-0.008	-0.6	1
S 23.1684	4345.787	.....	-0.006	4345.677	+0.104	+7.2	2
S 25.7688	4367.033	.....	-0.023	4367.012	-0.002	-0.1	1
Ti 29.0872	4395.246	-0.045	.....	4395.201	.....	.....	.....
Ti 29.6321	4399.994	-0.059	.....	4399.935	.....	.....	.....
S 31.3521	4415.211	.....	-0.057	4415.076	+0.078	+5.3	2
S 31.5819	4417.271	.....	-0.057	4417.121	+0.093	+6.3	1
Ti 31.6566	4417.941	-0.057	.....	4417.884	.....	.....	.....
Ti 37.0948	Standard	±0.000	.....	4468.663	.....	.....	.....
S 37.4102	4471.723	.....	-0.001	4471.676	+0.046	+3.1	1
Ti 38.4027	4481.441	-0.003	.....	4481.438	.....	.....	.....
S 38.4103	4481.516	.....	-0.003	4481.400	+0.113	+7.6	1
Ti 45.2667	4552.561	+0.071	.....	4552.632	.....	.....	.....
S 45.2827	4552.735	.....	+0.071	4552.750	+0.056	+3.7	3
Ti 46.2989	4563.886	+0.053	.....	4563.939	.....	.....	.....
S 46.6572	4567.858	.....	+0.056	4567.950	-0.036	-2.4	2
Ti 47.0375	4572.097	+0.059	.....	4572.156	.....	.....	.....
S 47.2942	4574.972	.....	+0.055	4574.900	+0.127	+8.3	1
Ti 50.9749	Standard	±0.000	.....	4617.452	.....	.....	.....

Curvature Cor.+0.0009 mm.

Weighted mean

+3.8

Mean +3.8

$V_a$  +18.40

$V_d$  +0.23

Reduction to Sun +18.63

Radial Velocity +22.4 km.

SUMMARY OF MEASURES OF § PERSEI.

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 226	1901, Sept. 12	+22.5	7	.....	..
A 235	Sept. 18	+23.2	5	.....	..
B 218	Nov. 8	+23.0	8	+21.9	8
B 232	Nov. 14	+21.5	7	+20.3	11
B 424	1902, Oct. 15	+22.4	10	.....	..

Mean +22.5

+21.1

Mean of 5 plates +22.3 km.

Mean of all measures +22.1 km.

6. β ORIONIS.

(R. A. = 5<sup>h</sup> 10<sup>m</sup>; Dec. = -8° 19'; Mag. 0.3; Class VIc)

Especial attention has been given to the investigation of this well-known star because of the Potsdam observations of 1890, which seemed to indicate a variation in its radial velocity. A total of nineteen plates extending over an interval of six months have been measured, five by E., and nineteen by A. The results do not indicate any variation of velocity. The spectrum of this star is characterized by the strength of its *Orion* lines and the existence of several faint metallic lines. The breadth of these lines is the chief difficulty in the way of accurate measurement.

1901, September 4, G. M. T. 21<sup>h</sup> 43<sup>m</sup>  
Hour angle E 2<sup>h</sup> 29<sup>m</sup>

$\beta$  ORIONIS—A 207  
Star strong; comparison good.

Measured by A. with Zeiss Comparator  
Power 18

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 62.4073	Standard	$\pm 0.000$	.....	4338.084			
S 62.1758	4340.544	.....	$\pm 0.000$	4340.634	-0.090	-6.2	1
S 57.8843	4387.998	.....	-0.005	4388.100	-0.107	7.3	1
<i>Ti</i> 57.2599	4395.207	-0.006	.....	4395.201			
<i>Ti</i> 56.8542	Standard	$\pm 0.000$	.....	4399.935			
<i>Ti</i> 52.1340	4457.600	$\pm 0.000$	.....	4457.600			
<i>Ti</i> 51.2739	4468.665	-0.002	.....	4468.663			
S 51.0433	4471.662	.....	-0.002	4471.676	-0.016	1.1	1
S 50.3072	4481.319	.....	$\pm 0.000$	4481.400	-0.081	5.4	1
<i>Ti</i> 50.2982	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor. -0.0002 mm.

Weighted mean - 5.0

Mean -5.0

$$V_a + 25.24$$

$$V_d + 0.20$$

Reduction to Sun +25.44

Radial Velocity +20.4 km.

1901, October 3, G. M. T. 19<sup>h</sup> 26<sup>m</sup>  
Hour angle E 2<sup>h</sup> 49<sup>m</sup>

$\beta$  ORIONIS—A 262  
Star good; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 19.2059	Standard	$\pm 0.000$	.....	4338.084			
S 23.7369	4388.179	.....	-0.046	4388.100	+0.033	+2.2	1
<i>Ti</i> 24.7553	4399.992	-0.057	.....	4399.935			
S 27.8874	4437.700	.....	-0.005	4437.718	-0.023	-1.6	1
<i>Ti</i> 28.3915	4443.972	+0.004	.....	4443.976			
<i>Ti</i> 28.8172	Standard	$\pm 0.000$	.....	4449.313			
<i>Ti</i> 30.3524	4468.668	-0.005	.....	4468.663			
S 30.5638	4471.672	.....	-0.001	4471.676	-0.005	-0.3	1
S 31.3043	4481.374	.....	+0.014	4481.400	-0.012	-0.8	1
<i>Ti</i> 31.3081	4481.424	+0.014	.....	4481.438			
<i>Ti</i> 37.2144	Standard	$\pm 0.000$	.....	4553.939			
S 37.4833	4567.928	.....	$\pm 0.000$	4567.950	-0.022	-1.4	1

Curvature Cor. +0.0001 mm.

Weighted mean - 0.4

Mean -0.4

$$V_a + 22.92$$

$$V_d + 0.23$$

Reduction to Sun +23.15

Radial Velocity +22.8 km.

1901, October 18, G. M. T. 20<sup>h</sup> 7<sup>m</sup>  
Hour angle E 1<sup>h</sup> 12<sup>m</sup>

$\beta$  ORIONIS—B 207  
Star good; comparison good.

Measured by A.  
Power 24

<i>Ti</i> 22.9731	Standard	$\pm 0.000$	.....	4338.084			
S 23.3055	4340.709	.....	-0.001	4340.634	+0.074	+5.1	2
S 29.0872	4388.203	.....	-0.019	4388.100	+0.084	5.7	1
<i>Ti</i> 29.9062	4395.223	-0.022	.....	4395.201			
S 34.6936	4437.824	.....	-0.003	4437.718	+0.103	7.0	1
<i>Ti</i> 35.3601	Standard	$\pm 0.000$	.....	4443.976			
<i>Ti</i> 37.9741	4468.654	+0.009	.....	4468.663			
S 38.2864	4471.663	.....	+0.017	4471.676	+0.004	0.3	3
S 39.2846	4481.367	.....	+0.045	4481.400	+0.012	0.8	4
<i>Ti</i> 39.2873	4481.393	+0.045	.....	4481.438			
<i>Ti</i> 45.8676	Standard	$\pm 0.000$	.....	4548.938			
<i>Ti</i> 46.2087	4552.618	+0.014	.....	4552.632			
S 46.2208	4552.749	.....	+0.014	4552.750	+0.013	0.9	1

Curvature Cor. +0.0002 mm.

Weighted mean + 2.3

Mean +3.3

$$V_a + 19.38$$

$$V_d + 0.10$$

Reduction to Sun +19.48

Radial Velocity +21.8 km.

$\beta$  ORIONIS B 207Measured by F.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	microns	microns	microns	microns	microns	km.	
Ti 19.675	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 19.994	4340.604	.....	-0.003	4340.634	-0.033	-2.3	1
Ti 25.656	4387.079	-0.072	.....	4387.007	.....	.....	.....
S 25.777	4388.105	.....	-0.070	4388.100	-0.065	-4.4	1
Ti 30.239	4427.276	-0.010	.....	4427.266	.....	.....	.....
Ti 34.680	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 34.996	4471.705	.....	+0.008	4471.676	+0.037	+2.5	2
S 35.984	4481.303	.....	+0.035	4481.400	-0.062	-4.2	3
Ti 35.994	4481.403	+0.035	.....	4481.438	.....	.....	.....
Ti 43.959	4563.906	+0.033	.....	4563.939	.....	.....	.....
S 44.327	4567.954	.....	+0.029	4567.950	+0.033	+2.2	2
Ti 46.308	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Weighted mean

-1.1

Mean -1.2

Curvature Cor.

-0.17

 $V_a + 19.38$  $V_d + 0.10$ 

Reduction to Sun

+19.48

Radial Velocity

+18.2 km.

 $\beta$  ORIONIS A 2841901, October 31, G. M. T. 19<sup>h</sup> 58<sup>m</sup>Hour angle E 0<sup>h</sup> 29<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

S 23.5148	4340.641	.....	$\pm 0.000$	4340.634	+0.007	+0.5	2
Ti 23.5983	Standard	$\pm 0.000$	.....	4341.530	.....	.....	.....
Ti 27.7147	4387.009	-0.002	.....	4387.007	.....	.....	.....
S 27.8156	4388.166	.....	-0.002	4388.100	+0.064	4.7	3
Ti 29.2155	Standard	$\pm 0.000$	.....	4404.433	.....	.....	.....
Ti 34.2076	4465.956	+0.019	.....	4465.975	.....	.....	.....
S 34.6543	4471.772	.....	+0.012	4476.676	+0.108	7.2	3
S 35.9907	4481.400	.....	$\pm 0.000$	4481.400	$\pm 0.000$	0.0	3
Ti 35.9895	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....

Curvature Cor. +0.0005 mm.

Weighted mean

+ 3.2

Mean +3.0

 $V_a + 15.23$  $V_d + 0.04$ 

Reduction to Sun

+15.27

Radial Velocity

+18.5 km.

 $\beta$  ORIONIS B 2131901, November 7, G. M. T., 18<sup>h</sup> 6<sup>m</sup>Hour angle E 1<sup>h</sup> 50<sup>m</sup>

Star good; comparison fair.

Measured by A.  
Power 21

S 33.3753	4388.314	.....	$\pm 0.000$	4388.100	+0.214	+14.6	1
Ti 34.7200	Standard	$\pm 0.000$	.....	4389.935	.....	.....	.....
Ti 42.2191	4468.689	-0.026	.....	4468.663	.....	.....	.....
S 42.5474	4471.862	.....	0.020	4471.676	+0.166	11.1	1
Ti 43.5294	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 43.5355	4481.498	.....	$\pm 0.000$	4481.400	+0.098	6.6	2
Ti 46.3061	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean

+ 9.7

Mean +10.8

 $V_a + 12.67$  $V_d + 0.16$ 

Reduction to Sun

+12.83

Radial Velocity

+22.5 km.

$\beta$  ORIONIS - B 2201901, November 8, G. M. T. 20<sup>h</sup> 6<sup>m</sup>  
Hour angle W 0° 10<sup>m</sup>

Star good; comparison slightly weak.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 20.1587	Standard	±0.000	.....	4338.084			
S 20.4953	4340.749	.....	-0.001	4340.634	+0.114	+7.9	2
S 21.9256	4352.202	.....	-0.005	4352.083	+0.114	7.9	2
S 26.2738	4388.332	.....	-0.018	4388.100	+0.214	14.6	1
<i>Ti</i> 27.0757	4395.221	-0.020	.....	4395.201			
<i>Ti</i> 32.5195	Standard	±0.000	.....	4443.976			
<i>Ti</i> 35.1300	4468.661	+0.002	.....	4468.663			
S 35.4584	4471.830	.....	+0.004	4471.676	+0.158	10.6	2
<i>Ti</i> 36.4438	4481.427	+0.011	.....	4481.438			
S 36.4585	4481.587	.....	+0.011	4481.400	+0.198	13.2	3
<i>Ti</i> 45.1340	Standard	±0.000	.....	4572.156			
S 46.2063	4584.173	.....	±0.000	4584.018	+0.155	10.1	1

Curvature Cor. +0.0009 mm.

Weighted mean

+10.7

Mean +10.7

 $V_a + 12.25$  $V_d - 0.01$ 

Reduction to Sun

+12.24

Radial Velocity

+22.9 km.

 $\beta$  ORIONIS - B 2311901, November 14, G. M. T. 19<sup>h</sup> 19<sup>m</sup>  
Hour angle E 0° 15<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 18.6998	Standard	±0.000	.....	4338.084			
S 19.0460	4340.831	.....	-0.003	4340.634	+0.194	+13.4	1
<i>Ti</i> 24.6539	4387.055	-0.048	.....	4387.007			
S 24.7978	4388.286	.....	-0.047	4388.100	+0.139	9.5	1
<i>Ti</i> 33.6420	4468.662	+0.001	.....	4468.663			
S 33.9775	4471.906	.....	+0.001	4471.676	+0.231	15.5	1
<i>Ti</i> 34.9543	Standard	±0.000	.....	4481.438			
S 34.9709	4481.601	.....	±0.000	4481.400	+0.201	13.4	3
S 44.7033	4584.259	.....	±0.000	4584.018	+0.241	15.8	1
<i>Ti</i> 45.2195	Standard	±0.000	.....	4590.126			

Curvature Cor. +0.0008 mm.

Weighted mean

+13.5

Mean +13.5

 $V_a + 9.85$  $V_d + 0.02$ 

Reduction to Sun

+ 9.87

Radial Velocity

+23.4 km.

 $\beta$  ORIONIS - B 2371901, November 15, G. M. T. 18<sup>h</sup> 52<sup>m</sup>  
Hour angle E 0° 35<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 20.7414	Standard	±0.000	.....	4338.084			
S 21.0810	4340.777	.....	-0.002	4340.634	+0.141	+9.7	1
<i>Ti</i> 26.6980	4387.049	-0.042	.....	4387.007			
S 26.8506	4388.354	.....	-0.041	4388.100	+0.213	14.5	2
<i>Ti</i> 34.3108	Standard	±0.000	.....	4455.485			
<i>Ti</i> 35.6896	4468.656	+0.007	.....	4468.663			
S 36.0229	4471.878	.....	+0.012	4471.676	+0.214	14.4	3
<i>Ti</i> 37.0002	4481.412	+0.026	.....	4481.438			
S 37.0130	4481.538	.....	+0.026	4481.400	+0.164	11.0	4
S 46.7429	4584.143	.....	+0.001	4584.018	+0.126	8.2	1
<i>Ti</i> 47.2694	Standard	±0.000	.....	4590.126			

Curvature Cor. +0.0008 mm.

Weighted mean

+12.2

Mean +11.6

 $V_a + 9.44$  $V_d + 0.05$ 

Reduction to Sun

+ 9.49

Radial Velocity

+21.7 km.

1901, November 27, G. M. T. 21<sup>h</sup> 22<sup>m</sup>  
Hour angle W 2° 43<sup>m</sup>

 $\beta$  ORIONIS — B 252

Star good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 18.1164	Standard	$\pm 0.000$	.....	4338.084			
S 18.4616	4340.849	.....	-0.004	4340.634	+0.211	+14.6	1
Ti 24.0166	4387.076	-0.069	.....	4387.007			
S 24.1593	4388.308	.....	-0.068	4388.100	+0.140	9.6	1
Ti 32.9216	Standard	$\pm 0.000$	.....	4468.663			
S 33.2565	4471.959	.....	+0.003	4471.676	+0.286	19.2	2
Ti 34.2210	4481.424	+0.014	.....	4481.438			
S 34.2413	4481.625	.....	+0.014	4481.400	+0.239	16.0	3
Ti 44.4023	Standard	$\pm 0.000$	.....	4590.126			

Curvature Cor. +0.0009 mm.

Weighted mean +15.8

Mean +14.8

$V_a$  +4.23

$V_d$  -0.22

Reduction to Sun +4.01

Radial Velocity +19.8 km.

1901, December 18, G. M. T. 18<sup>h</sup> 12<sup>m</sup>  
Hour angle W 0° 56<sup>m</sup>

 $\beta$  ORIONIS — B 257

Star good; comparison good.

Measured by A.  
Power 21

Ti 17.0931	Standard	$\pm 0.000$	.....	4338.084			
S 17.4562	4341.007	.....	-0.002	4340.634	+0.371	+25.6	1
Ti 22.9621	4387.039	-0.032	.....	4387.007			
S 23.1360	4388.547	.....	-0.032	4388.100	+0.415	28.4	2
Ti 31.4164	Standard	$\pm 0.000$	.....	4464.617			
S 32.1790	4472.068	.....	+0.032	4471.676	+0.424	28.4	3
Ti 33.1190	4481.363	+0.075	.....	4481.438			
S 33.1516	4481.687	.....	+0.075	4481.400	+0.362	24.2	2
S 42.7563	4584.341	.....	$\pm 0.000$	4584.018	+0.323	21.1	1
Ti 43.2620	Standard	$\pm 0.000$	.....	4590.126			

Curvature Cor. +0.0007 mm.

Weighted mean +26.3

Mean +25.6

$V_a$  -5.14

$V_d$  -0.08

Reduction to Sun 5.22

Radial Velocity +21.1 km.

1901, December 19, G. M. T. 17<sup>h</sup> 34<sup>m</sup>  
Hour angle W 0° 23<sup>m</sup>

 $\beta$  ORIONIS — A 297

Star good; comparison good.

Measured by A.  
Power 21

Ti 21.0590	Standard	$\pm 0.000$	.....	4338.084			
S 21.3084	4341.000	.....	-0.002	4340.634	+0.364	+25.2	1
Ti 25.4010	4387.040	-0.033	.....	4387.007			
S 25.5270	4388.511	.....	-0.029	4388.100	+0.382	26.1	2
Ti 26.4958	Standard	$\pm 0.000$	.....	4468.663			
Ti 31.2842	4468.652	+0.011	.....	4468.663			
S 32.2453	4472.091	.....	+0.008	4471.676	+0.423	28.4	2
Ti 32.9465	Standard	$\pm 0.000$	.....	4481.438			
S 32.9680	4481.726	.....	$\pm 0.000$	4481.400	+0.326	21.8	2

Curvature Cor. +0.0006 mm.

Weighted mean +25.4

Mean +25.4

$V_a$  -5.58

$V_d$  -0.93

Reduction to Sun 5.61

Radial Velocity +19.8 km.

1901, December 31, G. M. T. 15<sup>h</sup> 12<sup>m</sup>  
Hour angle E 1<sup>h</sup> 12<sup>m</sup>

$\beta$  ORIONIS — B 261  
Star good ; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 23.8840	4341.118	.....	± 0.000	4340.634	+0.484	+33.4	2
Ti 23.9354	Standard	± 0.000	.....	4341.530	.....	.....	.....
Ti 29.4018	4387.014	-0.007	.....	4387.007	.....	.....	.....
S 29.5832	4388.581	.....	-0.006	4388.100	+0.475	32.5	1
Ti 31.3940	Standard	± 0.000	.....	4404.433	.....	.....	.....
Ti 37.8867	4464.638	-0.021	.....	4464.617	.....	.....	.....
S 38.6513	4472.097	.....	-0.012	4471.676	+0.409	27.4	3
Ti 39.5972	Standard	± 0.000	.....	4481.438	.....	.....	.....
S 39.6438	4481.901	.....	± 0.000	4481.400	+0.501	33.5	4

Curvature Cor. +0.0008 mm.

Weighted mean +31.6

Mean +31.7

$$\begin{array}{r} V_a - 10.69 \\ V_d + 0.10 \end{array}$$

Reduction to Sun -10.59

Radial Velocity +21.0 km.

$\beta$  ORIONIS — B 261

Measured by F.  
Power 12

S 29.9627	4341.268	.....	+0.001	4340.634	+0.635	+43.9	1
Ti 30.3581	Standard	± 0.000	.....	4344.451	.....	.....	.....
Ti 35.4653	4387.066	-0.059	.....	4387.007	.....	.....	.....
S 35.6385	4388.562	.....	-0.059	4388.100	+0.403	27.5	1
Ti 39.9853	Standard	± 0.000	.....	4427.266	.....	.....	.....
Ti 44.0880	4465.969	+0.006	.....	4465.975	.....	.....	.....
S 44.7186	4472.117	.....	+0.003	4471.676	+0.444	29.8	3
Ti 45.6641	Standard	± 0.000	.....	4481.438	.....	.....	.....
S 45.7128	4481.921	.....	± 0.000	4481.400	+0.521	34.9	3

Weighted mean +33.2  
Curvature Cor. - 0.82

Mean +34.0

$$\begin{array}{r} V_a - 10.69 \\ V_d + 0.10 \end{array}$$

Reduction to Sun -10.59

Radial Velocity +21.8 km.

$\beta$  ORIONIS — A 300

1902, January 4, G. M. T. 17<sup>h</sup> 44<sup>m</sup>  
Hour angle W 1<sup>h</sup> 35<sup>m</sup>

Star strong ; comparison good.

Measured by A.  
Power 21

Ti 22.4561	Standard	± 0.000	.....	4338.084	.....	.....	.....
S 22.7409	4341.162	.....	-0.003	4340.634	+0.525	+36.3	1
Ti 26.8268	4387.053	-0.046	.....	4387.007	.....	.....	.....
S 26.9671	4388.688	.....	-0.043	4388.100	+0.545	37.2	2
Ti 28.8668	Standard	± 0.000	.....	4411.240	.....	.....	.....
Ti 33.4260	4468.678	-0.015	.....	4468.663	.....	.....	.....
S 33.6985	4472.269	.....	-0.011	4471.676	+0.582	39.0	2
Ti 34.3880	Standard	± 0.000	.....	4481.438	.....	.....	.....
S 34.4196	4481.861	.....	± 0.000	4481.400	+0.461	30.8	3

Curvature Cor. +0.0005 mm.

Weighted mean +35.2

Mean +35.8

$$\begin{array}{r} V_a - 12.35 \\ V_d - 0.14 \end{array}$$

Reduction to Sun -12.49

Radial Velocity +22.7 km.

1902, January 8, G. M. T. 18<sup>h</sup> 15<sup>m</sup>  
 Hour angle W 2<sup>h</sup> 24<sup>m</sup>

$\beta$  ORIONIS—A 306

Star good; comparison good.

Measured by A.  
 Power 20

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 26.0198	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 26.3109	4341.220	.....	$\pm 0.000$	4340.634	+0.586	+40.5	1
S 30.5367	4388.582	.....	$\pm 0.000$	4388.100	+0.482	32.9	1
Ti 31.5042	Standard	$\pm 0.000$	.....	4389.935	.....	.....	.....
Ti 37.0198	4468.652	+0.011	.....	4468.663	.....	.....	.....
S 37.2933	4472.248	.....	+0.008	4471.676	+0.580	38.9	2
Ti 37.9859	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 38.0223	4481.924	.....	$\pm 0.000$	4481.400	+0.524	35.1	1

Curvature Cor. +0.0005 mm.

Weighted mean +37.2

Mean +36.8

$V_a$  -13.92

$V_d$  -0.20

Reduction to Sun -14.12

Radial Velocity +23.1 km.

1902, January 9, G. M. T. 14<sup>h</sup> 41<sup>m</sup>  
 Hour angle E 1<sup>h</sup> 14<sup>m</sup>

$\beta$  ORIONIS—B 270

Star good; comparison good.

Measured by A.  
 Power 21

Ti 18.3004	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 24.3850	4388.587	.....	$\pm 0.000$	4388.100	+0.487	+33.3	1
Ti 25.6876	Standard	$\pm 0.000$	.....	4389.935	.....	.....	.....
Ti 33.1168	4468.654	+0.009	.....	4468.663	.....	.....	.....
S 33.4863	4472.261	.....	+0.007	4471.676	+0.592	39.7	1
Ti 34.4178	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 34.4691	4481.947	.....	$\pm 0.000$	4481.400	+0.547	36.5	2
Ti 44.6069	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....
Ti 50.1609	Standard	$\pm 0.000$	.....	4656.644	.....	.....	.....
Ti 54.3252	Standard	$\pm 0.000$	.....	4710.368	.....	.....	.....
S 54.5924	4713.937	.....	$\pm 0.000$	4713.308	+0.629	40.0	1

Curvature Cor. +0.0008 mm.

Weighted mean +37.2

Mean +37.4

$V_a$  -14.24

$V_d$  +0.11

Reduction to Sun -14.13

Radial Velocity +23.1 km.

$\beta$  ORIONIS—B 270

Measured by F.  
 Power 13

S 29.9906	4341.124	.....	-0.001	4340.634	+0.489	+33.8	2
Ti 30.0412	Standard	$\pm 0.000$	.....	4341.530	.....	.....	.....
Ti 35.5109	4387.073	-0.067	.....	4387.007	.....	.....	.....
S 35.7116	4388.806	.....	-0.069	4388.100	+0.637	43.5	2
Ti 44.1458	4465.986	-0.011	.....	4465.975	.....	.....	.....
Ti 44.7062	4471.435	-0.027	.....	4471.408	.....	.....	.....
S 44.7878	4472.231	.....	-0.013	4471.676	+0.542	36.3	3
Ti 45.7229	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 45.7722	4481.917	.....	$\pm 0.000$	4481.400	+0.517	34.6	3
Ti 65.6312	Standard	$\pm 0.000$	.....	4682.088	.....	.....	.....
Ti 65.6312	4710.406	-0.038	.....	4710.368	.....	.....	.....
S 65.8922	4713.901	.....	-0.038	4713.308	+0.555	35.3	1

Weighted mean +36.5

Mean +36.7

Curvature Cor. 0.82

$V_a$  -14.24

$V_d$  +0.11

Reduction to Sun -14.13

Radial Velocity +21.6 km.

1902, January 16, G. M. T. 17<sup>h</sup> 3<sup>m</sup>  
Hour angle W 1<sup>h</sup> 46<sup>m</sup>

$\beta$  ORIONIS—B 277  
Star good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 17.2623	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 17.6427	4341.132	.....	-0.002	4340.634	+0.496	+34.3	1
<i>Ti</i> 23.1558	4387.042	-0.035	.....	4387.007	.....	.....	.....
<i>Ti</i> 24.6347	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
S 28.8554	4438.179	.....	+0.046	4437.718	+0.507	34.3	1
<i>Ti</i> 29.4687	4443.923	+0.053	.....	4443.976	.....	.....	.....
<i>Ti</i> 32.0516	4468.657	+0.006	.....	4468.663	.....	.....	.....
S 32.4205	4472.263	.....	+0.004	4471.676	+0.591	39.6	3
<i>Ti</i> 33.3503	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 33.3924	4481.856	.....	$\pm 0.000$	4481.400	+0.456	30.5	2
S 43.0322	4584.478	.....	$\pm 0.000$	4584.018	+0.460	30.1	1
<i>Ti</i> 43.5254	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....
<i>Ti</i> 49.0727	Standard	$\pm 0.000$	.....	4656.644	.....	.....	.....
<i>Ti</i> 53.2285	Standard	$\pm 0.000$	.....	4710.368	.....	.....	.....
S 53.4933	4713.913	.....	$\pm 0.000$	4713.308	+0.605	38.5	2

Curvature Cor. +0.0008 mm.

Weighted mean +35.6

Mean +34.5

$$\begin{array}{r} V_a - 16.81 \\ V_d - 0.15 \end{array}$$

Reduction to Sun -16.96

Radial Velocity +18.6 km.

$\beta$  ORIONIS—B 277

Measured by F. with Zeiss Comparator  
Power 17

S 24.4155	4341.181	.....	$\pm 0.000$	4340.634	+0.547	+37.8	2
<i>Ti</i> 24.4587	Standard	$\pm 0.000$	.....	4341.530	.....	.....	.....
<i>Ti</i> 29.8992	4387.055	-0.048	.....	4387.007	.....	.....	.....
S 30.0715	4388.550	.....	-0.048	4388.100	+0.402	27.5	3
<i>Ti</i> 38.4880	Standard	$\pm 0.000$	.....	4465.975	.....	.....	.....
<i>Ti</i> 39.0440	4471.412	-0.004	.....	4471.408	.....	.....	.....
S 39.1255	4472.213	.....	-0.004	4471.676	+0.533	35.7	2
<i>Ti</i> 40.0540	4481.398	+0.040	.....	4481.438	.....	.....	.....
S 40.0652	4481.808	.....	+0.040	4481.400	+0.448	30.0	4
<i>Ti</i> 44.1042	4522.918	+0.058	.....	4522.974	.....	.....	.....
S 44.1345	4523.237	.....	+0.058	4522.802	+0.493	32.7	1
S 49.7010	4584.492	.....	+0.005	4584.018	+0.479	31.3	$\frac{1}{2}$
<i>Ti</i> 50.1905	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0011 mm.

Weighted mean +31.82

Mean +32.5

$$\begin{array}{r} V_a - 16.81 \\ V_d - 0.15 \end{array}$$

Reduction to Sun -16.96

Radial Velocity +14.9 km.

$\beta$  ORIONIS—B 282

1902, January 24, G. M. T. 12<sup>h</sup> 50<sup>m</sup>  
Hour angle E 2<sup>h</sup> 00<sup>m</sup>

Star good; comparison good.

Measured by F. with Zeiss Comparator  
Power 13

<i>Ti</i> 32.207	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 32.586	4341.132	.....	$\pm 0.001$	4340.634	+0.497	+34.3	1
<i>Ti</i> 38.076	4387.024	-0.017	.....	4387.007	.....	.....	.....
S 38.257	4388.594	.....	-0.017	4388.100	+0.477	32.6	1
<i>Ti</i> 39.551	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
<i>Ti</i> 46.937	4468.665	-0.002	.....	4468.663	.....	.....	.....
S 47.309	4472.318	.....	-0.002	4471.676	+0.640	42.9	1
<i>Ti</i> 48.229	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 48.288	4482.026	.....	$\pm 0.000$	4481.400	+0.626	41.9	2

Curvature Cor. +0.0011 mm.

Weighted mean +38.7

Mean +37.9

$$\begin{array}{r} V_a - 19.32 \\ V_d + 0.17 \end{array}$$

Reduction to Sun -19.15

Radial Velocity +19.6 km.

$\beta$  ORIONIS—B 282Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 23.2788	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 23.6556	4341.106	.....	$\pm 0.000$	4340.634	+0.472	+32.6	2
S 29.3646	4388.745	.....	$\pm 0.000$	4388.100	+0.645	44.1	2
Ti 30.1065	Standard	$\pm 0.000$	.....	4395.201	.....	.....	.....
Ti 31.9213	4411.266	-0.026	.....	4411.240	.....	.....	.....
S 32.6320	4417.665	.....	-0.023	4417.121	+0.521	35.4	1
Ti 38.0620	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 38.4323	4472.283	.....	$\pm 0.000$	4471.676	+0.607	40.7	3
Ti 39.3653	4481.488	-0.050	.....	4481.438	.....	.....	.....
S 39.4324	4482.028	.....	-0.050	4481.400	+0.578	38.7	1
Ti 55.0843	Standard	$\pm 0.000$	.....	4656.644	.....	.....	.....
Ti 57.0867	Standard	$\pm 0.000$	.....	4682.088	.....	.....	.....
Ti 58.3815	Standard	$\pm 0.000$	.....	4698.946	.....	.....	.....
S 59.5088	4713.891	.....	$\pm 0.000$	4713.308	+0.583	37.1	3

Curvature Cor. +0.0008 mm.

Weighted mean

+38.4

Mean +38.1

 $V_a$  -19.32 $V_d$  +0.17

Reduction to Sun

-19.15

Radial Velocity

+19.2 km.

 $\beta$  ORIONIS—A 312Measured by A.  
Power 211902, February 10, G. M. T. 14<sup>h</sup> 54<sup>m</sup>  
Hour angle, W 1<sup>h</sup> 10<sup>m</sup>

Star good; comparison good.

Ti 25.3630	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 25.6543	4341.234	.....	-0.001	4340.634	+0.599	+41.4	2
Ti 29.7287	4387.019	-0.012	.....	4387.007	.....	.....	.....
S 29.8806	4388.791	.....	-0.011	4388.100	+0.680	46.4	1
Ti 31.7702	Standard	$\pm 0.000$	.....	4411.240	.....	.....	.....
S 33.9747	4438.429	.....	+0.007	4437.718	+0.718	48.5	1
Ti 34.4129	4443.967	+0.009	.....	4443.976	.....	.....	.....
Ti 36.3238	4468.657	+0.006	.....	4468.663	.....	.....	.....
S 36.6981	4472.407	.....	+0.004	4471.676	+0.735	49.3	3
Ti 37.2864	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 37.3279	4481.994	.....	$\pm 0.000$	4481.400	+0.594	39.7	3

Curvature Cor.+0.0005 mm.

Weighted mean

+44.5

Mean +45.1

 $V_a$  -23.47 $V_d$  -0.10

Reduction to Sun

-23.57

Radial Velocity

+20.9 km.

 $\beta$  ORIONIS—A 330Measured by A.  
Power 211902, March 3, G. M. T. 13<sup>h</sup> 44<sup>m</sup>  
Hour angle W 1<sup>h</sup> 23<sup>m</sup>

Star good; comparison good.

Ti 22.3238	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 22.6222	4341.307	.....	$\pm 0.000$	4340.634	+0.673	+46.5	2
Ti 26.6919	4386.978	+0.029	.....	4387.007	.....	.....	.....
S 26.8922	4388.658	.....	+0.027	4388.100	+0.585	40.0	2
Ti 27.7949	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
Ti 33.2668	4468.672	-0.009	.....	4468.663	.....	.....	.....
S 33.5810	4472.377	.....	-0.006	4471.676	+0.695	46.6	4
Ti 34.2024	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 34.3070	4482.035	.....	$\pm 0.000$	4481.400	+0.635	42.5	3

Curvature Cor.+0.0005 mm.

Weighted mean

+44.3

Mean +43.9

 $V_a$  -25.63 $V_d$  -0.12

Reduction to Sun

-25.75

Radial Velocity

+18.5 km.

SUMMARY OF MEASURES OF  $\beta$  ORIONIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A207	1901, Sept. 4	+20.4	4	.....	..
A262	Oct. 3	+22.8	5	.....	..
B207	Oct. 18	+21.8	6	+18.2	5
A284	Oct. 31	+18.5	4	.....	..
B213	Nov. 7	+22.5	3	.....	..
B220	Nov. 8	+22.9	6	.....	..
B231	Nov. 14	+23.4	5	.....	..
B237	Nov. 15	+21.7	5	.....	..
B252	Nov. 27	+19.8	4	.....	..
B257	Dec. 18	+21.1	5	.....	..
A297	Dec. 19	+19.8	4	.....	..
B261	Dec. 31	+21.0	4	+21.8	4
A300	1902, Jan. 4	+22.7	4	.....	..
A306	Jan. 8	+23.1	4	.....	..
B270	Jan. 9	+23.1	4	+21.6	5
B277	Jan. 16	+18.6	6	+14.9	5
B282	Jan. 24	+19.2	6	+19.6	4
A312	Feb. 10	+20.9	5	.....	..
A330	Mar. 3	+18.5	4	.....	..

Mean +21.1 +19.2  
Mean of 19 plates +20.9 km.  
Mean of all measures +20.7 km.

7.  $\gamma$  ORIONIS

(R. A.=5<sup>h</sup> 20<sup>m</sup>; Dec.=+6° 15'; Mag. 1.9; Class IVa)

Seven plates of this star have been measured, six by A., and four by F., with three common to the two observers. An interesting systematic difference seems to exist in the two sets of measures, which is probably due to the different personality effects which enter into the settings upon the broad lines of the star spectrum. The general features of this spectrum are very similar to those of  $\zeta$  Persei.

 $\gamma$  ORIONIS — A224

1901, September 11, G. M. T. 21<sup>h</sup> 32<sup>m</sup>  
Hour angle E 2<sup>h</sup> 17<sup>m</sup>

Star fair; comparison rather weak.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 26.0285	4340.459	.....	±0.000	4340.634	-0.175	-12.1	4
H 26.0449	Standard	±0.000	.....	4340.634	.....	.....	.....
S 30.3242	4387.938	.....	-0.056	4388.100	-0.218	14.9	2
Ti 30.9596	4395.266	-0.065	.....	4395.201	.....	.....	.....
Ti 36.9536	Standard	±0.000	.....	4468.663	.....	.....	.....
S 37.1664	4471.419	.....	+0.028	4471.676	-0.229	15.4	2
Hc 37.1849	4471.648	+0.028	.....	4471.676	.....	.....	.....
S 37.9127	4481.174	.....	+0.027	4481.400	-0.199	13.3	4
Ti 42.8823	4549.788	+0.020	.....	4549.808	.....	.....	.....
S 43.0712	4552.529	.....	+0.018	4552.750	-0.203	13.4	1
Ti 43.8492	4563.926	+0.013	.....	4563.939	.....	.....	.....
S 44.1047	4567.708	.....	+0.007	4567.950	-0.235	15.4	1
Ti 44.4036	Standard	±0.000	.....	4572.156	.....	.....	2
S 44.5777	4574.759	.....	±0.000	4574.900	-0.141	9.2	.....

Curvature Cor.+0.0001 mm.

Weighted mean - 13.1

Mean - 13.4

$$V_a + 28.31$$

$$V_a + 0.19$$

Reduction to Sun +28.50

Radial Velocity +15.4 km.

1901, October 2, G. M. T. 21<sup>h</sup> 34<sup>m</sup>

Hour angle E 0° 47'

## γ ORIONIS—A 258

Star good; comparison good.

Measured by A.

Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 18.1261	Standard	±0.000	.....	4338.084	.....	.....	.....
S 18.3507	4340.474	.....	-0.001	4340.634	-0.161	-11.1	1
Ti 22.5613	4387.039	-0.032	.....	4387.007	.....	.....	.....
S 22.6451	4388.001	.....	-0.032	4388.100	-0.131	9.0	2
Ti 23.6768	4399.961	-0.026	.....	4399.935	.....	.....	.....
S 24.9370	4414.871	.....	-0.016	4415.076	-0.221	15.0	1
Ti 25.9640	4427.274	-0.008	.....	4427.266	.....	.....	.....
S 26.7986	4437.526	.....	-0.004	4437.718	-0.196	13.2	1
Ti 27.7427	Standard	±0.000	.....	4449.313	.....	.....	.....
Ti 29.2569	4468.653	+0.010	.....	4468.663	.....	.....	.....
S 29.4801	4471.551	.....	+0.013	4471.676	-0.112	7.5	2
S 30.2139	4481.163	.....	+0.026	4481.400	-0.211	14.1	1
Ti 30.2728	4481.412	+0.026	.....	4481.438	.....	.....	.....
Ti 36.1383	Standard	±0.000	.....	4563.939	.....	.....	.....
S 36.3967	4567.774	.....	±0.000	4567.950	-0.176	11.6	1

Curvature Cor. + 0.0001 mm.

Weighted mean

-10.9

Mean - 11.6

 $V_{\alpha} + 26.61$  $V_d + 0.07$ 

Reduction to Sun

+ 26.68

Radial Velocity

+ 15.8 km.

## γ ORIONIS—B 221

1901, November 8, G. M. T. 20<sup>h</sup> 38<sup>m</sup>

Hour angle W 0° 32'

Star fair; comparison good.

Measured by A.

Power 14

Ti 20.0778	Standard	±0.000	.....	4338.084	.....	.....	.....
S 20.4666	4340.706	.....	-0.001	4340.634	+0.071	+4.9	1
Ti 26.0447	4387.035	0.028	.....	4387.007	.....	.....	.....
S 26.1716	4388.118	.....	-0.026	4388.100	-0.008	-0.6	2
Ti 27.5425	Standard	±0.000	.....	4399.935	.....	.....	.....
Ti 35.0484	4468.668	-0.005	.....	4468.663	.....	.....	.....
S 35.3599	4471.642	.....	0.004	4471.676	-0.038	-2.5	1
Ti 36.3996	Standard	±0.000	.....	4481.438	.....	.....	.....
S 36.3929	4481.461	.....	±0.000	4481.400	+0.061	+4.1	1
S 43.2769	4552.791	.....	±0.000	4552.750	+0.041	+2.7	1
Ti 43.5444	Standard	±0.000	.....	4555.662	.....	.....	.....
Ti 44.3937	4563.962	-0.023	.....	4563.939	.....	.....	.....
S 44.6755	4568.060	.....	-0.018	4567.950	+0.092	+6.0	3
Ti 46.6437	4590.128	-0.002	.....	4590.126	.....	.....	.....
Ti 49.0940	Standard	±0.000	.....	4617.452	.....	.....	.....
Ti 52.2489	4656.637	±0.007	.....	4656.644	.....	.....	.....
Ti 54.2731	Standard	±0.000	.....	4682.088	.....	.....	.....
Ti 56.4512	4710.389	-0.021	.....	4710.368	.....	.....	.....
S 56.6702	4713.289	.....	-0.021	4713.308	-0.040	-2.5	3

Curvature Cor. + 0.0009 mm.

Weighted mean

+ 1.6

Mean + 1.7

 $V_{\alpha} + 15.47$  $V_d - 0.05$ 

Reduction to Sun

+ 15.42

Radial Velocity

+ 17.0 km.

$\gamma$  ORIONIS-B 221Measured by F.  
Power 15

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>T</i> 30.0031	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
<i>S</i> 30.1385	4388.164	.....	-0.001	4388.100	+0.063	+ 4.3	3
<i>S</i> 33.2198	4415.067	.....	-0.035	4415.076	-0.044	- 3.0	1
<i>T</i> 33.2198	4417.922	-0.038	.....	4417.884	.....	.....	.....
<i>T</i> 38.7276	4465.997	-0.022	.....	4465.975	.....	.....	.....
<i>S</i> 39.3271	4471.773	.....	-0.014	4471.676	+0.083	+ 5.6	3
<i>T</i> 40.3191	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
<i>S</i> 40.3295	4481.540	.....	$\pm 0.000$	4481.400	+0.140	+ 9.4	$\frac{1}{2}$
<i>T</i> 47.2247	4552.601	+0.031	.....	4552.632	.....	.....	.....
<i>S</i> 47.2543	4552.924	.....	+0.031	4552.750	+0.202	+13.3	$1\frac{1}{2}$
<i>T</i> 47.5037	4555.627	+0.035	.....	4555.662	.....	.....	.....
<i>S</i> 48.6214	4567.875	.....	+0.016	4567.950	-0.059	- 3.9	1
<i>T</i> 50.6058	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean + 4.8

Mean + 4.3

$$\begin{array}{r} V_a +15.47 \\ V_d - 0.05 \end{array}$$

Reduction to Sun +15.42

Radial Velocity +20.2 km.

 $\gamma$  ORIONIS-B 2531901, November 27, G. M. T. 21<sup>h</sup> 55<sup>m</sup>  
Hour angle W 3<sup>h</sup> 8<sup>m</sup>Star strong; not quite centrally  
between comparison spectra.Measured by F.  
Power 14

S	4340.732	.....	+0.067	4340.634	+0.165	+11.4	2
<i>T</i> 29.9995	4341.463	+0.067	.....	4341.530	.....	.....	.....
<i>T</i> 35.4665	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
<i>S</i> 35.6305	4388.424	.....	$\pm 0.000$	4388.100	+0.324	22.1	2
<i>T</i> 39.9635	4427.264	+0.002	.....	4427.266	.....	.....	.....
<i>S</i> 41.1325	4437.783	.....	-0.001	4437.718	+0.064	4.3	$\frac{1}{2}$
<i>T</i> 42.3615	4449.318	-0.005	.....	4449.313	.....	.....	.....
<i>T</i> 44.1005	Standard	$\pm 0.000$	.....	4465.975	.....	.....	.....
<i>S</i> 44.7040	4471.850	.....	+0.004	4471.676	+0.178	11.9	3
<i>T</i> 45.6765	4481.423	+0.013	.....	4481.438	.....	.....	.....
<i>S</i> 45.7025	4481.680	.....	+0.013	4481.400	+0.293	19.6	$\frac{1}{2}$
<i>T</i> 52.5135	4552.592	+0.040	.....	4552.632	.....	.....	.....
<i>S</i> 52.5510	4553.002	.....	+0.035	4552.750	+0.287	18.9	1
<i>T</i> 52.7915	4555.638	+0.024	.....	4555.662	.....	.....	.....
<i>S</i> 53.9210	4568.144	.....	+0.020	4567.950	+0.214	14.0	2
<i>T</i> 55.8615	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0015 mm.

Weighted mean +14.7

Mean +14.6

$$\begin{array}{r} V_a +6.75 \\ V_d -0.25 \end{array}$$

Reduction to Sun + 6.50

Radial Velocity +21.2 km.

$\gamma$  ORIONIS—B 262

1902, December 31, G. M. T. 15<sup>h</sup> 38<sup>m</sup>  
 Hour angle E 0<sup>h</sup> 58<sup>m</sup>

Star good; comparison good.

Measured by A.  
 Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 30.1486	4471.434	-0.026	.....	4471.408			
S 30.2116	4472.051	.....	-0.026	4471.676	+0.349	+23.4	2
Ti 31.1632	Standard	$\pm 0.000$	.....	4481.438			
Ti 37.9928	4552.617	+0.015	.....	4552.632			
S 38.0449	4553.187	.....	+0.015	4552.750	+0.452	29.8	1
Ti 41.3381	Standard	$\pm 0.000$	.....	4590.126			
S 41.4567	4591.490	.....	$\pm 0.000$	4591.066	+0.424	27.7	1
S 44.0480	4621.909	.....	+0.023	4621.549	+0.383	24.8	1
Ti 44.1903	4623.255	+0.023	.....	4623.279			
S 46.3328	4649.742	.....	+0.012	4649.250	+0.504	32.5	2
Ti 46.8864	4656.635	+0.009	.....	4656.644			
Ti 50.1830	4698.940	+0.006	.....	4698.946			
S 50.2450	4699.757	.....	+0.006	4699.340	+0.423	27.0	2
Ti 51.0447	Standard	$\pm 0.000$	.....	4710.368			
S 51.2930	4713.690	.....	$\pm 0.000$	4713.308	+0.382	24.3	2

Curvature Cor. +0.0008 mm.

Weighted mean +27.0

Mean +27.1

$$\begin{aligned} V_a & -10.03 \\ V_d & +0.09 \end{aligned}$$

Reduction to Sun - 9.94  
 Radial Velocity +17.1 km.

 $\gamma$  ORIONIS—B 262

Measured by F.  
 Power 12

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 35.003	4341.413	+0.117	.....	4341.530			
S 34.936	4340.873	.....	+0.119	4340.634	+0.358	+24.7	1
Ti 40.467	Standard	$\pm 0.000$	.....	4387.007			
S 40.633	4388.443	.....	$\pm 0.000$	4388.100	+0.343	23.4	2
Ti 44.988	4427.267	-0.001	.....	4427.266			
S 46.158	4438.088	.....	-0.017	4437.718	+0.353	23.8	1 $\frac{1}{2}$
Ti 46.420	4440.535	-0.020	.....	4440.515			
Ti 49.062	4465.995	-0.020	.....	4465.975			
S 49.729	4472.204	.....	-0.013	4471.676	+0.515	34.5	2
Ti 50.696	Standard	$\pm 0.000$	.....	4481.438			
S 50.690	4481.676	.....	$\pm 0.000$	4481.400	+0.276	18.5	1
Ti 57.498	4552.615	+0.017	.....	4552.632			
S 57.553	4553.212	.....	+0.019	4552.750	+0.481	31.7	1 $\frac{1}{2}$
Ti 57.774	4555.635	+0.027	.....	4555.662			
S 58.936	4568.509	.....	+0.018	4567.950	+0.577	37.9	1
S 59.550	4575.402	.....	+0.011	4574.900	+0.513	33.6	1 $\frac{1}{2}$
Ti 60.843	Standard	$\pm 0.000$	.....	4590.126			
S 60.963	4591.507	.....	-0.001	4591.066	+0.440	28.7	1 $\frac{1}{2}$
Ti 67.276	4667.868	-0.100	.....	4667.768			
Ti 69.689	4699.101	-0.155	.....	4698.946			
Ti 70.551	4710.558	-0.190	.....	4710.368			
S 70.807	4713.992	.....	-0.201	4713.308	+0.483	30.7	1

Curvature Cor. +0.001 mm.

Weighted mean +28.9

Mean +28.8

$$\begin{aligned} V_a & -10.03 \\ V_d & +0.09 \end{aligned}$$

Reduction to Sun - 9.94  
 Radial Velocity +19.0 km.

1902, March 13, G. M. T. 15<sup>h</sup> 53<sup>m</sup>  
Hour angle W 3<sup>h</sup> 58<sup>m</sup>

$\gamma$  ORIONIS B 299  
Star fair; comparison good.

Measured by A.  
Power 20

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>T</i> <sub>i</sub> 18.2322	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 21.8613	4367.681	.....	-0.021	4367.012	+0.648	+44.5	2
<i>T</i> <sub>i</sub> 21.8827	4367.860	-0.021	.....	4367.839	.....	.....	.....
S 27.6440	4417.817	.....	-0.062	4417.121	+0.634	43.0	1
<i>T</i> <sub>i</sub> 27.6583	4417.946	-0.062	.....	4417.884	.....	.....	.....
<i>T</i> <sub>i</sub> 32.8061	Standard	$\pm 0.000$	.....	4465.975	.....	.....	.....
S 33.4598	4472.321	.....	+0.008	4471.676	+0.653	43.8	2
<i>T</i> <sub>i</sub> 34.3868	4481.420	+0.018	.....	4481.438	.....	.....	.....
S 34.4508	4482.052	.....	+0.018	4481.400	+0.670	44.8	1
<i>T</i> <sub>i</sub> 42.2737	4563.904	+0.035	.....	4563.939	.....	.....	.....
S 42.6969	4568.637	.....	+0.022	4567.950	+0.709	46.5	2
<i>T</i> <sub>i</sub> 43.0140	4572.145	+0.011	.....	4572.156	.....	.....	.....
<i>T</i> <sub>i</sub> 44.6012	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean +44.7

Mean +44.5

$V_a$  -28.63

$V_d$  -0.29

Reduction to Sun -28.92

Radial Velocity +15.8 km.

1902, April 9, G. M. T. 15<sup>h</sup> 4<sup>m</sup>  
Hour angle W 4<sup>h</sup> 56<sup>m</sup>

$\gamma$  ORIONIS B 317  
Star too weak; comparison strong.

Measured by A.  
Power 17

<i>T</i> <sub>i</sub> 22.9221	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
S 23.1170	4388.687	.....	+0.000	4388.100	+0.587	+40.1	2
<i>T</i> <sub>i</sub> 31.5791	4465.985	-0.010	.....	4465.975	.....	.....	.....
S 32.2371	4472.376	.....	-0.006	4471.676	+0.694	46.5	3
<i>T</i> <sub>i</sub> 33.1599	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 33.2137	4481.970	.....	$\pm 0.000$	4481.400	+0.570	38.1	1
<i>T</i> <sub>i</sub> 40.0166	4552.609	+0.023	.....	4552.632	.....	.....	.....
S 40.0909	4553.420	.....	+0.022	4552.750	+0.692	45.6	1
<i>T</i> <sub>i</sub> 43.3733	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....
S 43.5163	4591.706	.....	$\pm 0.000$	4591.066	+0.692	45.7	1

Curvature Cor. +0.0008 mm.

Weighted mean +43.6

Mean +43.2

$V_a$  -24.92

$V_d$  -0.33

Reduction to Sun -25.25

Radial Velocity +18.4 km.

$\gamma$  ORIONIS—B 317

Measured by F.  
Power 12

<i>T</i> <sub>i</sub> 35.001	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
S 35.188	4388.618	.....	$\pm 0.000$	4388.109	+0.518	+35.4	2
<i>T</i> <sub>i</sub> 37.764	4411.224	+0.016	.....	4411.240	.....	.....	.....
S 38.287	4415.903	.....	+0.010	4415.076	.....	.....	.....
<i>T</i> <sub>i</sub> 40.294	4434.187	-0.019	.....	4434.168	+0.837	+56.8	1
S 40.739	4438.303	.....	-0.019	4437.718	+0.566	38.2	1
<i>T</i> <sub>i</sub> 43.662	4465.993	-0.018	.....	4465.975	.....	.....	.....
S 44.318	4472.368	.....	-0.007	4471.676	+0.685	45.9	2
<i>T</i> <sub>i</sub> 44.590	Standard	$\pm 0.000$	.....	4475.026	.....	.....	.....
<i>T</i> <sub>i</sub> 52.100	4552.616	+0.016	.....	4552.632	.....	.....	.....
<i>T</i> <sub>i</sub> 52.782	4560.076	+0.026	.....	4560.102	.....	.....	.....
S 53.363	4568.730	.....	+0.018	4567.950	+0.798	52.4	1
<i>T</i> <sub>i</sub> 55.457	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.001 mm.

Weighted mean +44.3

Mean +45.7

$V_a$  -24.92

$V_d$  -0.33

Reduction to Sun -25.25

Radial Velocity +19.0 km.

SUMMARY OF MEASURES OF  $\gamma$  ORIONIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 224	1901, Sept. 11	+15.4	7	.....	..
A 258	Oct. 2	+15.8	7	.....	..
B 221	Nov. 8	+17.0	7	+20.2	6
B 253	Nov. 27	.....	..	+21.2	7
B 262	Dec. 31	+17.1	7	+19.0	10
B 290	1902, Mar. 13	+15.8	5	.....	..
B 317	Apr. 9	+18.4	5	+19.0	4

Mean +16.6 +20.1

Mean of 7 plates +17.6 km.

Mean of all measures +18.0 km.

7.  $\epsilon$  ORIONIS

(R. A. =  $5^h 31^m$ ; Dec. =  $-1^\circ 16'$ ; Mag. 1.8; Class IIa)

Four plates of this star have been measured, three by F., and four by A. All of the lines in its spectrum are extremely broad and ill-defined, and the accuracy of measurement is probably less than for any other star in the list.

 $\epsilon$  ORIONIS—A 208

1901, September 4, G. M. T.  $22^h 10^m$   
Hour angle  $E 2^h 23^m$

Star rather strong; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 23.5347	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
Ti 34.7160	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 34.9557	4471.762	.....	$\pm 0.000$	4471.676	+0.086	+5.8	2
S 35.6890	4481.331	.....	+0.017	4481.400	-0.052	-3.5	2
Ti 35.6959	4581.421	+0.017	.....	4481.438	.....	.....	.....
Ti 40.8525	4552.648	-0.016	.....	4552.632	.....	.....	.....
S 40.8598	4552.738	.....	-0.016	4552.750	-0.012	-0.8	1
Ti 41.6242	Standard	$\pm 0.000$	.....	4563.939	.....	.....	.....

Curvature Cor. +0.0002 mm.

Weighted mean +0.8

Mean +0.5

$V_a + 26.52$

$V_d + 0.20$

Reduction to Sun +26.72

Radial Velocity +27.5 km.

 $\epsilon$  ORIONIS—B 228

1901, November 13, G. M. T.  $19^h 50^m$   
Hour angle  $E 0^h 29^m$

Star good; comparison strong.

Measured by A.  
Power 17

S 14.5020	4340.974	.....	$\pm 0.000$	4340.634	+0.340	+23.5	2
Ti 14.9362	Standard	$\pm 0.000$	.....	4344.451	.....	.....	.....
Ti 20.1023	4387.071	-0.064	.....	4387.007	.....	.....	.....
S 20.2405	4388.328	.....	-0.064	4388.100	+0.164	11.2	1 $\frac{1}{2}$
S 20.4612	4472.034	.....	-0.006	4471.676	+0.352	23.6	.....
Ti 30.4276	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
Ti 37.3358	4552.527	+0.105	.....	4552.632	.....	.....	.....
S 37.3726	4552.925	.....	+0.105	4552.750	+0.280	18.4	1 $\frac{1}{2}$
Ti 38.3732	4563.827	+0.112	.....	4563.939	.....	.....	.....
S 38.7223	4568.011	.....	+0.111	4567.950	+0.172	11.3	1
Ti 50.5289	Standard	$\pm 0.000$	.....	4710.368	.....	.....	.....
S 50.7662	4713.516	.....	$\pm 0.000$	4713.308	+0.208	13.2	4

Curvature Cor. +0.0008 mm.

Weighted mean +15.0

Mean +16.9

$V_a + 13.73$

$V_d + 0.04$

Reduction to Sun +13.77

Radial Velocity +28.8 km.

$\epsilon$  ORIONIS—B 228Measured by F.  
Power 12

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 30.777	4340.670	.....	$\pm 0.000$	4340.634	+0.036	+2.5	1
Ti 30.855	Standard	$\pm 0.000$	.....	4341.530	.....	.....	.....
Ti 36.390	4386.945	+0.062	.....	4387.007	.....	.....	.....
S 36.511	4387.982	.....	+0.062	4388.100	-0.058	-4.0	1
Ti 45.122	4465.995	-0.020	.....	4465.975	.....	.....	.....
S 45.734	4471.891	.....	-0.016	4471.676	+0.199	+13.3	2
Ti 48.216	Standard	$\pm 0.000$	.....	4496.318	.....	.....	.....
Ti 53.626	4552.612	+0.020	.....	4552.632	.....	.....	.....
S 53.648	4552.850	.....	+0.020	4552.750	+0.120	+7.9	1 <sub>2</sub>
Ti 66.817	Standard	$\pm 0.000$	.....	4710.368	.....	.....	.....
S 67.057	4713.548	.....	$\pm 0.000$	4713.308	+0.240	+15.3	3

Curvature Cor. +0.001 mm.

Weighted mean

+10.0

Mean + 7.0

 $V_a$  +13.73 $V_d$  + 0.04

Reduction to Sun

+13.77

Radial Velocity

+23.8 km.

 $\epsilon$  ORIONIS—B 298Measured by A.  
Power 141902, March 13, G. M. T. 15<sup>h</sup> 11<sup>m</sup>Hour angle W 3<sup>h</sup> 8<sup>m</sup>

Star rather weak; comparison good.

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 17.9470	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 18.3666	4341.438	.....	-0.004	4340.634	+0.800	+55.3	2
Ti 23.8632	4387.075	-0.068	.....	4387.007	.....	.....	.....
S 24.0678	4389.096	.....	-0.068	4388.100	+0.938	63.4	2
Ti 25.3515	4400.001	-0.066	.....	4399.935	.....	.....	.....
Ti 32.7994	4468.687	-0.024	.....	4468.663	.....	.....	.....
S 33.1848	4472.435	.....	-0.017	4471.676	+0.742	49.8	1
Ti 34.1023	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
Ti 41.9002	4563.879	+0.060	.....	4563.939	.....	.....	.....
S 42.4164	4568.606	.....	+0.067	4567.950	+0.716	47.0	1
S 48.5112	4639.666	.....	+0.011	4638.937	+0.740	47.8	2
Ti 49.8867	Standard	$\pm 0.000$	.....	4656.644	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean

+53.7

Mean +52.6

 $V_a$  -27.23 $V_d$  - 0.25

Reduction to Sun

-27.48

Radial Velocity

+26.2 km.

 $\epsilon$  ORIONIS—B 298Measured by F.  
Power 12

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 35.000	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
S 35.236	4389.041	.....	$\pm 0.000$	4388.100	+0.941	+64.3	2
Ti 44.222	4471.442	-0.034	.....	4471.408	.....	.....	.....
S 44.308	4472.280	.....	-0.031	4471.676	+0.573	38.4	2
Ti 45.241	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
Ti 52.100	4552.603	+0.029	.....	4552.632	.....	.....	.....
S 52.199	4553.683	.....	+0.029	4552.750	+0.962	63.4	1 <sub>2</sub>
Ti 53.129	4563.901	+0.038	.....	4563.939	.....	.....	.....
S 53.574	4568.840	.....	+0.039	4567.950	+0.929	61.0	1 <sub>2</sub>
Ti 55.455	4590.082	+0.044	.....	4590.126	.....	.....	.....
Ti 61.024	Standard	$\pm 0.000$	.....	4656.644	.....	.....	.....

Curvature Cor. +0.001 mm.

Weighted Mean

+53.5

Mean +56.8

 $V_a$  -27.23 $V_d$  - 0.25

Reduction to Sun

-27.48

Radial Velocity

+26.1 km.

*ε* ORIONIS—B 3161902, April 9, G. M. T. 14<sup>h</sup> 21<sup>m</sup>

Hour angle W 4 S

Star fair; comparison good.

Measured by A.  
Power 17

Mean of Settings	Wave-length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 24.3317	Standard	±0.000	.....	4388.084			
S 24.7620	4384.517	.....	±0.000	4380.634	+0.883	+61.1	1
Ti 30.2485	4387.016	-0.009	.....	4387.007			
S 30.4698	4388.921	.....	-0.009	4388.100	+0.812	55.5	1
Ti 31.7366	Standard	±0.000	.....	4399.935			
Ti 39.1836	4468.671	-0.008	.....	4468.663			
S 39.5633	4472.370	.....	-0.006	4471.676	+0.688	46.1	3
Ti 40.4855	Standard	±0.000	.....	4481.438			

Curvature Cor. +0.0008 mm.

Weighted mean +51.0

Mean +54.2

 $V_a = -24.24$  $V_d = 0.30$ 

Reduction to Sun 24.54

Radial Velocity +26.5 km.

*ε* ORIONIS—B 316Measured by F.  
Power 12

Ti 35.001	Standard	±0.000	.....	4387.007			
S 35.213	4388.835	.....	±0.000	4388.100	+0.735	+50.2	1
Ti 43.659	4466.001	-0.026	.....	4465.975			
S 44.327	4472.489	.....	-0.018	4471.676	+0.795	53.3	2
Ti 45.239	4481.444	-0.006	.....	4481.438			
Ti 48.354	Standard	±0.000	.....	4512.906			
Ti 53.127	4563.915	+0.024	.....	4563.939			
S 53.562	4568.742	.....	+0.015	4567.950	+0.807	53.0	1 <sub>2</sub>
Ti 55.456	4590.129	-0.003	.....	4590.126			
Ti 61.022	Standard	±0.000	.....	4656.644			

Curvature Cor. +0.001 mm.

Weighted mean +52.4

Mean +52.2

 $V_a = -24.24$  $V_d = 0.30$ 

Reduction to Sun 24.54

Radial Velocity +27.8 km.

SUMMARY OF MEASURES OF *ε* ORIONIS

Plate	Date	Waves	No. of Lines	Frost	No. of Lines
A 208	1901, Sept. 4	+27.5	3		
B 228	Nov. 13	+28.8	6	+23.8	5
B 298	1902, March 13	+26.2	5	+26.1	4
B 316	April 9	+26.5	3	+27.8	3

Mean +27.2 +25.9

Mean of 4 plates +26.8 km.

Mean of all measures +26.7 km.

S. *ζ* ORIONIS(R. A. = 5<sup>h</sup> 36<sup>m</sup>; Dec. = -2° 0'; Mag. 1.9; Class IIb)

Five plates of this star have been measured, five by A., and two by F. The spectrum is extremely difficult of measurement, the lines being few in number, and extremely broad and ill defined. The degree of accuracy attained is probably about the same as in the case of *ε* Orionis.

$\xi$  ORIONIS — A 2631901, October 3, G. M. T. 20<sup>h</sup> 42<sup>m</sup>Hour angle E 1<sup>h</sup> 56<sup>m</sup>

Star strong; comparison good.

Measured by A.

Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 21.3208	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 21.5491	4340.513	.....	$\pm 0.000$	4340.634	-0.121	- 8.4	2
<i>Ti</i> 24.0571	4367.836	+0.003	.....	4367.839			
<i>Ti</i> 25.7550	4387.026	-0.019	.....	4387.007			
<i>S</i> 25.8352	4387.947	.....	-0.017	4388.100	-0.170	11.6	3
<i>Ti</i> 26.8690	Standard	$\pm 0.000$	.....	4399.935			
<i>Ti</i> 29.1549	4427.249	.....	.....	4427.266			
<i>S</i> 29.9907	4457.524	+0.017	.....	4437.718	-0.181	12.2	2
<i>Ti</i> 32.4466	4468.655	+0.008	.....	4468.663			
<i>S</i> 32.6629	4471.467	.....	$\pm 0.000$	4471.676	-0.203	13.6	2
<i>Ti</i> 33.4230	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor. +0.0002 mm.

Weighted mean

-11.5

Mean -11.2

 $V_a + 25.58$  $V_d + 0.17$ 

Reduction to Sun

+25.75

Radial Velocity

+14.3 km.

 $\xi$  ORIONIS — A 263

Measured by F.

Power 12

<i>Ti</i> 31.0582	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 31.2891	4340.543	.....	-0.002	4340.634	-0.093	-6.4	1
<i>Ti</i> 36.6062	4399.977	-0.042	.....	4399.935			
<i>Ti</i> 42.1840	4468.668	-0.005	.....	4468.663			
<i>S</i> 42.4116	4471.623	.....	-0.004	4471.676	-0.057	3.8	1
<i>Ti</i> 43.1606	Standard	$\pm 0.000$	.....	4481.438			
<i>Ti</i> 49.0647	Standard	$\pm 0.000$	.....	4563.939			

Curvature Cor. +0.0003 mm.

Weighted mean

-5.1

Mean -5.1

 $V_a + 25.58$  $V_d + 0.17$ 

Reduction to Sun

+25.75

Radial Velocity

+20.8 km.

 $\xi$  ORIONIS — B 4291902, October 23, G. M. T. 23<sup>h</sup> 45<sup>m</sup>Hour angle W 2<sup>h</sup> 25<sup>m</sup>

Star good; comparison weak.

Measured by A.

Power 21

<i>Ti</i> 21.1865	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 21.5038	4340.609	.....	$\pm 0.000$	4340.634	-0.025	-1.7	1
<i>S</i> 27.2283	4387.981	.....	$\pm 0.000$	4388.100	-0.119	8.1	1
<i>Ti</i> 28.0643	Standard	$\pm 0.000$	.....	4395.201			
<i>S</i> 30.3115	4415.012	.....	$\pm 0.000$	4415.076	-0.058	3.9	1
<i>Ti</i> 31.6671	4427.256	+0.010	.....	4427.266			
<i>Ti</i> 36.0733	Standard	$\pm 0.000$	.....	4468.663			
<i>S</i> 36.9883	4471.527	.....	$\pm 0.000$	4471.676	-0.149	10.0	1

Curvature Cor. +0.0008 mm.

Weighted mean

-5.9

Mean -5.9

 $V_a + 21.40$  $V_d - 0.20$ 

Reduction to Sun

+21.20

Radial Velocity

+15.3 km.

## § ORIONIS—B 433

1902, October 29, G. M. T. 19<sup>h</sup> 4<sup>m</sup>Hour angle E 1<sup>h</sup> 52<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	μm.	μm.	μm.	μm.	μm.	km.	
Ti 21 4584	Standard	±0.000	.....	4338.084			
S 21 6687	4340.560	.....	±0.000	4340.634	-0.074	-5.1	2
S 21 9074	4395.905	.....	+0.004	4397.012	-0.013	-0.9	2
S 27 4009	4388.120	.....	+0.007	4388.100	+0.027	+1.8	1
Ti 38 2178	4395.193	+0.008	.....	4395.201			
Ti 38 5905	Standard	±0.000	.....	4399.935			
S 32 8292	4437.701	.....	+0.015	4437.718	-0.002	-0.1	2
Ti 33 6183	4443.959	+0.017	.....	4443.976			
Ti 36 2684	4468.670	-0.007	.....	4468.663			
S 36 5154	4471.647	.....	-0.005	4471.676	-0.029	-2.3	2
Ti 37 5123	Standard	±0.000	.....	4481.438			

Curvature Cor. +0.0008 mm.

Weighted mean - 1.6

Mean -0.7

$$V_a + 19.67$$

$$V_d + 0.16$$

Reduction to Sun +19.83

Radial Velocity +18.2 km.

## § ORIONIS—B 434

1902, October 29, G. M. T. 19<sup>h</sup> 45<sup>m</sup>Hour angle E 1<sup>h</sup> 52<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

Ti 20.1420	Standard	±0.000	.....	4338.084			
S 20 6650	4340.682	.....	±0.000	4340.634	+0.028	+1.9	1
S 26 1626	4387.943	.....	-0.003	4388.100	0.160	10.9	1
Ti 27 0014	4395.205	-0.004	.....	4395.201			
Ti 27.5428	Standard	+0.000	.....	4399.935			
Ti 34 9650	4468.682	-0.019	.....	4468.663			
S 35 3917	4471.665	.....	-0.015	4471.676	-0.026	-1.7	3
Ti 36.2973	Standard	±0.000	.....	4481.438			

Curvature Cor. +0.0008 mm.

Weighted mean - 2.9

Mean -3.6

$$V_a + 19.66$$

$$V_d + 0.11$$

Reduction to Sun +19.77

Radial Velocity +16.9 km.

## § ORIONIS—B 441

1902, October 30, G. M. T. 21<sup>h</sup> 19<sup>m</sup>Hour angle W 0<sup>h</sup> 27<sup>m</sup>

Star strong; comparison good.

Measured by A.  
Power 21

Ti 26 7297	Standard	±0.000	.....	4338.084			
S 26 6480	4340.692	.....	±0.000	4340.634	+0.058	+1.0	1
S 26 9658	4388.067	.....	+0.001	4388.100	-0.032	-2.2	1
Ti 27 1369	4395.200	+0.001	.....	4395.201			
Ti 27 3396	Standard	±0.000	.....	4399.935			
Ti 35 1942	4468.676	-0.013	.....	4468.663			
S 35 3949	4471.589	.....	-0.010	4471.676	-0.097	-6.5	1
Ti 36.4984	Standard	±0.000	.....	4481.438			

Curvature Cor. +0.0009 mm.

Weighted mean 1.6

Mean -1.6

$$V_a + 19.31$$

$$V_d - 0.04$$

Reduction to Sun +19.27

Radial Velocity +17.7 km.

$\zeta$  ORIONIS — B 441Measured by F.  
Power 12

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 30.1739	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 30.5197	4340.840	.....	$\pm 0.000$	4340.634	+0.206	+14.2	1
Ti 33.8288	4367.844	-0.005	.....	4367.839	.....	.....	.....
S 36.2503	4388.347	.....	-0.022	4388.100	+0.225	15.4	1
Ti 37.5895	4399.968	-0.033	.....	4399.935	.....	.....	.....
S 39.5276	4417.155	.....	-0.026	4417.121	+0.008	0.5	2
Ti 39.6117	4417.910	-0.026	.....	4417.884	.....	.....	.....
Ti 45.0495	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 45.3616	4471.692	.....	$\pm 0.000$	4471.676	+0.016	1.1	2
Ti 54.9951	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean

+ 5.5

Mean +7.8

 $V_a$  +19.31 $V_d$  - 0.04

Reduction to Sun

+19.27

Radial Velocity

+24.7 km.

SUMMARY OF MEASURES OF  $\zeta$  ORIONIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 263	1901, Oct. 3	+14.3	4	+20.6	2
B 429	1902, Oct. 23	+15.3	4	.....	.....
B 433	Oct. 29	+18.2	5	.....	.....
B 434	Oct. 29	+16.9	3	.....	.....
B 441	Oct. 30	+17.7	3	+24.7	4

Mean +16.5

+22.7

Mean of 5 plates +17.8 km.

Mean of all measures +18.3 km.

9.  $\kappa$  ORIONIS(R. A. =  $5^h 43^m$ ; Dec. =  $9^\circ 42'$ ; Mag. 2.2; Class IIa)

Seven plates of the spectrum of this star have been measured, seven by A., and three by F. The spectrum is one of the most difficult of measurement of any we have encountered, all the lines being very broad and diffuse. Traces of a few oxygen lines appear.

1901, September 20, G. M. T. 22<sup>h</sup> 13<sup>m</sup>  
Hour angle E 1<sup>h</sup> 23<sup>m</sup> $\kappa$  ORIONIS — A 244

Star good; comparison good.

Measured by A.  
Power 21

Ti 18.0699	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 18.3024	4340.560	.....	-0.001	4340.634	-0.075	- 5.2	1
S 19.2969	4351.296	.....	-0.009	4351.495	-0.208	14.3	1
S 22.5847	4387.979	.....	-0.031	4388.100	-0.152	10.4	1
Ti 23.2128	4395.237	-0.036	.....	4395.201	.....	.....	.....
Ti 27.2579	Standard	$\pm 0.000$	.....	4443.976	.....	.....	.....
Ti 29.1978	4468.656	+0.007	.....	4468.663	.....	.....	.....
S 29.4133	4471.452	.....	+0.008	4471.676	-0.216	14.5	1
Ti 35.3084	4552.591	+0.041	.....	4552.632	.....	.....	.....
S 35.3104	4552.620	.....	+0.041	4552.750	-0.089	5.9	2
Ti 36.0815	Standard	$\pm 0.000$	.....	4563.939	.....	.....	.....

Curvature Cor. +0.0001 mm.

Weighted mean

- 9.3

Mean -10.0

 $V_a$  +24.79 $V_d$  + 0.12

Reduction to Sun

+24.91

Radial Velocity

+15.6 km.

## \* ORIONIS B 241

Measured by F.  
Power 12

Mean of Settings	Wave-Length by Interpos.	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 28.9665	Standard	$\pm 0.000$	...	4338.084	...	...	...
S 29.2247	4340.480	-0.002	-0.002	4340.034	-0.156	-10.8	1
S 33.3022	4387.817	...	-0.040	4388.100	-0.323	-22.1	2
Ti 34.1468	4385.247	-0.046	...	4385.201	...	...	...
Ti 40.1331	Standard	$\pm 0.000$	...	4468.663	...	...	...
S 40.3458	4471.397	...	+0.006	4471.676	-0.273	-18.3	2½
Ti 41.1082	4481.400	+0.029	...	4481.438	...	...	...
Ti 46.2450	4552.632	$\pm 0.000$	...	4552.632	...	...	...
S 46.2533	4552.753	...	+0.003	4552.750	+0.003	+0.2	1
Ti 47.0149	Standard	$\pm 0.000$	...	4563.939	...	...	...
S 47.2816	4567.896	...	-0.011	4567.950	-0.065	-4.3	1
Ti 47.5686	4572.179	-0.023	...	4572.156	...	...	...

Curvature Cor. +0.0003 mm.

Weighted mean -14.0

Mean -11.1

 $V_r = +24.79$  $V_d = -0.12$ 

Reduction to Sun +24.91

Radial Velocity +10.9 km.

## \* ORIONIS A 250

Measured by A.  
Power 211901, September 26, G. M. T. 21<sup>h</sup> 26<sup>m</sup>  
Hour angle E 1<sup>h</sup> 50<sup>m</sup>

Star fair; comparison rather strong.

Ti 37.3388	Standard	$\pm 0.000$	...	4387.007	...	...	...
Ti 38.4583	4390.949	-0.014	...	4390.935	...	...	...
S 39.7340	4415.011	...	-0.017	4415.076	-0.082	-5.6	1
Ti 40.7524	4427.285	-0.019	...	4427.266	...	...	...
S 41.5941	4477.596	...	-0.022	4477.718	-0.144	9.7	1
Ti 42.5370	4449.339	-0.026	...	4449.313	...	...	...
S 44.2858	4471.661	...	-0.008	4471.676	-0.023	1.5	1
S 45.0288	4481.400	...	$\pm 0.000$	4481.400	-0.034	2.3	1
Ti 45.6943	Standard	$\pm 0.000$	...	4481.438	...	...	...
Ti 50.9555	4563.880	+0.050	...	4563.939	...	...	...
S 51.2177	4567.764	...	+0.043	4567.950	-0.143	9.4	1
Ti 52.7046	Standard	$\pm 0.000$	...	4590.126	...	...	...

Curvature Cor. +0.0001 mm.

Weighted mean 5.7

Mean -5.7

 $V_r = +24.55$  $V_d = +0.16$ 

Reduction to Sun +24.71

Radial Velocity +19.0 km.

## \* ORIONIS B 196

Measured by A.  
Power 241901, October 17, G. M. T. 19<sup>h</sup> 24<sup>m</sup>  
Hour angle E 2<sup>h</sup> 32<sup>m</sup>

Star good; comparison strong.

Ti 16.8722	Standard	$\pm 0.000$	...	4338.084	...	...	...
S 17.1483	4340.587	...	-0.001	4340.634	-0.048	-3.3	1
S 22.3038	4387.966	...	-0.013	4388.100	-0.147	-10.0	1
Ti 23.7479	4385.216	-0.015	...	4385.201	...	...	...
Ti 29.7642	Standard	$\pm 0.000$	...	4449.313	...	...	...
Ti 31.8021	4468.661	+0.002	...	4468.663	...	...	...
S 32.0694	4471.626	...	+0.002	4471.676	-0.048	-3.2	3
S 35.1166	4481.424	...	$\pm 0.000$	4481.400	+0.024	+1.6	2
Ti 36.2562	4512.913	-0.007	...	4481.438	...	...	...
Ti 40.0214	4552.615	+0.017	...	4552.632	...	...	...
S 40.0294	4552.939	...	+0.017	4552.750	-0.064	-4.2	2
Ti 41.0622	Standard	$\pm 0.000$	...	4563.939	...	...	...

Curvature Cor. +0.0002 mm.

Weighted mean 3.2

Mean -4.0

 $V_r = +21.65$  $V_d = +0.21$ 

Reduction to Sun +21.86

Radial Velocity +18.7 km.

1901, October 23, G. M. T. 19<sup>h</sup> 26<sup>m</sup>

κ ORIONIS—A 271

Measured by A.

Hour angle E 2<sup>h</sup> 1<sup>m</sup>

Star slightly weak; comparison good.

Power 25

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 25.3793	4388.096	.....	±0.000	4388.100	-0.004	-0.3	1
Ti 25.9654	Standard	±0.000	.....	4385.201	.....	.....	.....
S 27.6771	4414.992	.....	-0.042	4415.076	-0.126	8.6	1
Ti 27.9227	4417.933	-0.049	.....	4417.884	.....	.....	.....
Ti 31.9662	Standard	±0.000	.....	4468.663	.....	.....	.....
S 32.2265	4471.646	.....	±0.000	4471.676	-0.030	2.0	2
Ti 38.8937	Standard	±0.000	.....	4563.939	.....	.....	.....

Curvature Cor. +0.0002 mm.

Weighted mean - 3.2

Mean -3.6

 $V_a + 20.27$  $V_d + 0.17$ 

Reduction to Sun +20.44

Radial Velocity +17.2 km.

1901, October 31, G. M. T. 20<sup>h</sup> 24<sup>m</sup>

κ ORIONIS—A 285

Measured by A.

Hour angle E 0<sup>h</sup> 31<sup>m</sup>

Star good; comparison good.

Power 21

S 22.9041	4340.626	.....	±0.000	4340.634	-0.008	-0.6	1
Ti 23.2317	Standard	±0.000	.....	4344.451	.....	.....	.....
S 25.3370	4367.114	.....	-0.042	4367.012	+0.060	+4.1	1
Ti 25.4059	4367.881	-0.042	.....	4367.839	.....	.....	.....
Ti 27.1045	4387.067	-0.060	.....	4387.007	.....	.....	.....
S 27.1967	4388.159	-0.060	.....	4388.100	-0.001	-0.1	1
Ti 31.0726	4434.195	-0.027	.....	4434.168	.....	.....	.....
S 31.3647	4437.799	-0.030	.....	4437.718	+0.051	+3.4	2
Ti 32.2805	4449.349	-0.036	.....	4449.313	.....	.....	.....
Ti 33.5961	Standard	±0.000	.....	4465.975	.....	.....	.....
S 34.0413	4471.737	-0.009	.....	4471.676	+0.052	+3.5	2
Ti 34.7844	4481.462	-0.024	.....	4481.438	.....	.....	.....
Ti 39.9215	4552.599	+0.033	.....	4552.632	.....	.....	.....
S 39.9269	4552.677	+0.033	.....	4552.750	-0.040	-2.6	2
Ti 40.6932	4563.914	+0.025	.....	4563.939	.....	.....	.....
S 40.9627	4567.906	+0.019	.....	4567.950	-0.025	-1.6	2
Ti 42.4365	Standard	±0.000	.....	4590.126	.....	.....	.....
S 42.4965	4591.045	.....	±0.000	4591.066	-0.021	-1.4	2

Curvature Cor. +0.0005 mm.

Weighted mean + 0.5

Mean +0.6

 $V_a + 18.06$  $V_d + 0.04$ 

Reduction to Sun +18.10

Radial Velocity +18.6 km.

κ ORIONIS—A 285

Measured by F.

Power 12

Ti 29.9333	4338.076	+0.008	.....	4338.084	.....	.....	.....
S 30.1773	4340.739	.....	+0.005	4340.634	+0.110	+7.6	1
Ti 30.5306	Standard	±0.000	.....	4344.451	.....	.....	.....
Ti 34.3743	4387.069	-0.062	.....	4387.007	.....	.....	.....
S 34.4627	4388.083	-0.061	.....	4388.100	-0.078	-5.3	2
Ti 40.8675	4465.978	-0.003	.....	4465.975	.....	.....	.....
S 41.3154	4471.774	+0.002	.....	4471.676	+0.106	+7.1	2
Ti 42.0540	Standard	±0.000	.....	4481.438	.....	.....	.....
Ti 47.1927	4552.572	+0.060	.....	4552.632	.....	.....	.....
S 47.1932	4552.579	+0.060	.....	4552.750	-0.111	-7.3	3
Ti 51.8296	4623.251	+0.028	.....	4623.279	.....	.....	.....
Ti 52.2205	Standard	±0.000	.....	4629.521	.....	.....	.....
S 52.2904	4630.792	.....	±0.000	4630.703	+0.089	+5.8	1

Curvature Cor. +0.0010 mm.

Weighted mean - 0.6

Mean +1.6

 $V_a + 18.06$  $V_d + 0.04$ 

Reduction to Sun +18.10

Radial Velocity +17.5 km.

## \* ORIONIS — B 297

1902, March 13, G. M. T. 14<sup>h</sup> 29<sup>m</sup>  
Hour angle W 2° 14'

Star good; comparison good.

Measured by A.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 21 8680	4367.614	.....	±0.000	4367.012	+0.602	+41.3	1
Ti 21.8949	Standard	±0.000	.....	4367.839	.....	.....	.....
Ti 24.1685	4387.044	-0.037	.....	4387.007	.....	.....	.....
S 24 3666	4388.767	.....	-0.037	4388.100	+0.630	43.1	1
Ti 33.0949	Standard	±0.000	.....	4468.663	.....	.....	.....
S 33.4630	4472.243	.....	±0.000	4471.676	+0.567	38.0	2
Ti 34.3897	4481.437	+0.001	.....	4481.438	.....	.....	.....
S 34.4740	4482.172	.....	+0.001	4481.400	+0.773	51.7	1
Ti 41.2577	4552.608	+0.024	.....	4552.632	.....	.....	.....
S 41.3312	4553.410	.....	+0.024	4552.750	+0.684	45.0	2
Ti 43.0268	4572.147	+0.009	.....	4572.156	.....	.....	.....
S 43.3334	4575.586	.....	+0.009	4574.900	+0.693	45.4	1
Ti 44.6144	Standard	±0.000	.....	4590.126	.....	.....	.....
S 45.2168	4597.061	.....	±0.000	4596.291	+0.770	50.2	1

Curvature Cor. +0.0008 mm.

Weighted mean +44.2

Mean +45.0

$$V_a = -25.04$$

$$V_d = 0.19$$

Reduction to Sun -25.23

Radial Velocity +19.0 km.

## \* ORIONIS — B 315

1902, April 9, G. M. T. 13<sup>h</sup> 47<sup>m</sup>  
Hour angle W 3<sup>h</sup> 21<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 17

Ti 19.6236	Standard	+0.000	.....	4338.084	.....	.....	.....
S 20.0061	4341.163	.....	-0.002	4340.634	+0.527	+36.4	1
S 21.1303	4350.203	.....	-0.007	4349.541	+0.655	45.2	1
Ti 26.4805	4385.234	-0.033	.....	4385.201	.....	.....	.....
S 29.0285	4417.825	.....	-0.051	4417.121	+0.653	44.3	1
Ti 29.0507	4417.935	-0.051	.....	4417.884	.....	.....	.....
Ti 34.4790	Standard	±0.000	.....	4468.663	.....	.....	.....
S 34.8421	4472.193	.....	+0.007	4471.676	+0.524	35.1	1
Ti 35.7819	4481.414	+0.024	.....	4481.438	.....	.....	.....
S 35.8285	4481.973	.....	+0.024	4481.400	+0.597	40.0	1
Ti 42.6415	4552.582	+0.050	.....	4552.632	.....	.....	.....
S 42.7170	4553.406	.....	+0.050	4552.750	+0.706	46.5	2
Ti 43.6705	4563.884	+0.055	.....	4563.939	.....	.....	.....
S 46.1285	4591.592	.....	+0.037	4591.066	+0.563	36.8	1
Ti 48.3430	Standard	±0.000	.....	4617.452	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean +39.6

Mean +40.6

$$V_a = -22.86$$

$$V_d = 0.26$$

Reduction to Sun -23.12

Radial Velocity +16.5 km.

## \* ORIONIS — B 315

Measured by F.  
Power 12

Ti 20.0110	Standard	±0.000	.....	4338.084	.....	.....	.....
S 20.0000	4341.189	.....	±0.000	4340.634	+0.555	+38.3	1
Ti 26.8714	4385.214	-0.013	.....	4385.201	.....	.....	.....
Ti 44.8695	Standard	±0.000	.....	4468.663	.....	.....	.....
S 45.2432	4472.300	.....	+0.006	4471.676	+0.630	42.2	3
Ti 46.1721	4481.413	+0.025	.....	4481.438	.....	.....	.....
S 46.2375	4482.083	.....	+0.024	4481.400	+0.683	45.7	1
Ti 53.0431	4552.627	+0.005	.....	4552.632	.....	.....	.....
S 53.6668	4553.322	.....	+0.005	4552.750	+0.577	38.0	1
Ti 54.0610	4563.923	+0.016	.....	4563.939	.....	.....	.....
S 54.1791	4568.568	.....	+0.007	4567.950	+0.625	41.0	2
Ti 54.8003	Standard	±0.000	.....	4572.156	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean +41.4

Mean +41.0

$$V_a = -22.86$$

$$V_d = 0.26$$

Reduction to Sun -23.12

Radial Velocity +18.2 km.

SUMMARY OF MEASURES OF  $\kappa$  ORIONIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 244	1901, Sept. 20	+15.6	5	+10.9	5
A 250	Sept. 26	+19.0	5	.....	..
B 196	Oct. 17	+18.7	5	.....	..
A 274	Oct. 23	+17.2	3	.....	..
A 285	Oct. 31	+18.6	8	+17.5	5
B 297	1902, March 13	+19.0	7	.....	..
B 315	April 9	+16.5	7	+18.2	5

Mean +17.8 +15.5

Mean of 7 plates +17.5 km.

Mean of all measures +17.1 km.

10.  $\beta$  CANIS MAJORIS

(R. A. =  $6^h 18^m$ ; Dec. =  $-17^\circ 54'$ ; Mag. 2.0; Class IIIa)

Three plates of this star have been measured, two by A., and three by F. Numerous lines of oxygen and nitrogen are present in the spectrum in addition to the regular *Orion* lines, and all are narrow and well defined in character.

 $\beta$  CANIS MAJORIS — A 287

1901, October 31, G. M. T.  $21^h 35^m$   
Hour angle W  $0^h 9^m$

Star fair; comparison good.

Measured by A.  
Power 25

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 20.5223	Standard	$\pm 0.000$	.....	4344.451			
S 20.6539	4345.866	.....	-0.002	4345.677	+0.187	+12.9	1
S 21.0230	4349.850	.....	-0.008	4349.541	+0.301	20.7	$1_2$
S 21.1914	4351.676	.....	-0.011	4351.495	+0.170	11.7	$1_2$
S 22.6035	4367.197	.....	-0.036	4367.012	+0.149	10.2	$1_2$
<i>Ti</i> 22.6645	4367.876	-0.037	.....	4367.839			
<i>Ti</i> 26.4383	4411.311	-0.071	.....	4411.240			
S 26.7735	4415.310	.....	-0.083	4415.076	+0.151	10.3	2
S 26.9511	4417.438	.....	-0.090	4417.121	+0.227	15.4	$1_2$
<i>Ti</i> 26.9959	4417.976	-0.092	.....	4417.884			
<i>Ti</i> 30.8583	4466.035	-0.060	.....	4465.975			
S 31.3058	4471.956	.....	-0.037	4471.676	+0.243	16.3	2
<i>Ti</i> 32.0405	Standard	$\pm 0.000$	.....	4481.438			
<i>Ti</i> 37.1801	4552.558	+0.074	.....	4552.632			
S 37.2029	4552.890	.....	+0.074	4552.750	+0.214	14.1	2
<i>Ti</i> 37.9534	4563.885	+0.054	.....	4563.939			
S 38.2383	4568.101	.....	+0.053	4567.950	+0.204	13.4	1
<i>Ti</i> 38.5072	4572.103	+0.053	.....	4572.156			
S 38.7063	4575.080	.....	+0.056	4574.900	+0.236	15.5	2
<i>Ti</i> 39.6951	4590.041	+0.085	.....	4590.126			
<i>Ti</i> 41.4542	4617.406	+0.046	.....	4617.452			
S 42.2972	4630.872	.....	+0.036	4630.703	+0.205	13.3	$1_2$
S 42.8130	4639.228	.....	+0.029	4638.937	+0.320	20.7	1
S 42.9915	4642.140	.....	+0.027	4641.886	+0.281	18.2	$1_2$
S 43.5376	4651.119	.....	+0.020	4650.925	+0.214	13.8	$1_2$
<i>Ti</i> 43.8696	4656.628	+0.016	.....	4656.644			
<i>Ti</i> 44.5340	Standard	$\pm 0.000$	.....	4667.788			
S 45.0520	4676.563	.....	$\pm 0.000$	4676.290	+0.273	17.5	$1_2$

Curvature Cor. +0.0005 mm.

Weighted mean +14.7

Mean +14.9

$V_{\alpha}$  +18.84  
 $V_d$  - 0.01

Reduction to Sun +18.83

Radial Velocity +33.5 km.

*$\beta$  CANIS MAJORIS—A 287*Measured by F.  
Power 12

Measurements	Wave-lengths Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 31.0422	4367.190		$\pm 0.000$	4367.072	+0.118	+ 8.1	1
Ti 31.0005	Standard	$\pm 0.000$	.....	4367.839			
Ti 32.7005	4387.060	-0.053	.....	4387.007			
S 32.8075	4388.280	.....	-0.052	4388.100	+0.137	9.4	2
S 35.1105	4415.906	.....	-0.060	4415.076	+0.170	11.5	2
S 35.2828	4417.372	.....	-0.061	4417.121	+0.190	12.9	1
Ti 35.3308	4417.945	-0.061	.....	4417.884			
Ti 39.1925	4465.018	-0.043	.....	4465.975			
S 39.6468	4471.900	.....	-0.028	4471.676	+0.196	13.1	2
Ti 40.3755	Standard	$\pm 0.000$	.....	4481.438			
Ti 40.3815	4481.517	.....	$\pm 0.000$	4481.400	+0.117	7.8	1
Ti 45.5175	4552.620	+0.012	.....	4552.632			
S 45.5428	4552.988	.....	+0.012	4552.750	+0.250	16.5	3
Ti 46.2802	4563.883	+0.056	.....	4563.939			
Ti 46.5748	4568.156	.....	+0.027	4567.950	+0.233	15.3	2
Ti 46.8430	4572.149	+0.007	.....	4572.156			
S 47.0442	4575.159	.....	+0.006	4574.900	+0.265	17.4	1
Ti 48.0330	Standard	$\pm 0.000$	.....	4580.126			
S 48.4478	4596.494	.....	+0.001	4596.291	+0.204	13.3	1
Ti 49.7885	4617.445	+0.007	.....	4617.452			

Weighted mean  $+12.9$   
 Curvature Cor.  $- 0.71$

Mean + 12.5

$$\begin{aligned} V_a &+18.84 \\ V_d &- 0.03 \end{aligned}$$

Reduction to Sun  $+18.81$   
 Radial Velocity  $+31.0$  km.

 *$\beta$  CANIS MAJORIS—A 293*1901, November 1, G. M. T. 21<sup>h</sup> 26<sup>m</sup>  
Hour angle W 0<sup>h</sup> 3<sup>m</sup>

Star fair; comparison good.

Measured by F.  
Power 17

Measurements	Wave-lengths Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 27.1717	Standard	$\pm 0.000$	.....	4338.084			
S 27.4256	4340.791	.....	-0.005	4340.634	+0.152	10.5	1
S 31.7221	4388.419	.....	-0.062	4388.100	+0.257	17.6	2
Ti 32.3148	4395.270	-0.069	.....	4395.201			
Ti 32.7200	4399.998	-0.063	.....	4399.935			
S 34.0175	4415.363	.....	-0.064	4415.076	+0.223	15.2	2
S 34.1961	4417.503	.....	-0.063	4417.121	+0.319	21.6	1
Ti 34.2324	4417.939	-0.055	.....	4417.884			
Ti 35.0081	4427.332	-0.066	.....	4427.266			
Ti 38.9000	4468.635	-0.032	.....	4468.663			
S 38.4096	4471.936	.....	-0.009	4471.676	+0.251	16.8	2
Ti 39.2752	Standard	$\pm 0.000$	.....	4481.438			
Ti 43.7088	4552.552	+0.080	.....	4552.632			
S 44.4375	4552.974	.....	+0.062	4552.750	+0.286	18.8	1
Ti 45.1813	4563.883	+0.058	.....	4563.939			
S 45.4700	4568.169	.....	+0.067	4567.950	+0.286	18.8	3
Ti 45.7344	4572.069	+0.057	.....	4572.156			
S 46.0682	4591.222	.....	+0.064	4591.065	+0.220	14.4	2
Ti 48.0188	4617.416	+0.036	.....	4617.452			
S 49.0122	4631.181	.....	+0.025	4630.206	+0.260	16.8	2
S 50.6555	4649.413	.....	+0.011	4649.424	+0.184	11.9	2
Ti 51.0033	Standard	$\pm 0.000$	.....	4656.644			

Weighted mean  $+17.1$   
 Curvature Cor.  $- 0.86$

Mean + 16.2

$$\begin{aligned} V_a &+18.63 \\ V_d &- 0.00 \end{aligned}$$

Reduction to Sun  $+18.63$   
 Radial Velocity  $+34.8$  km.

$\beta$  CANIS MAJORIS — B 2151901, November 7, G. M. T. 21<sup>h</sup> 00<sup>m</sup>  
Hour angle, E 0<sup>h</sup> 8<sup>m</sup>

Star weak; comparison slightly weak.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 15.9494	Standard	$\pm 0.000$	.....	4313.034	.....	.....	.....
S 16.5293	4317.457	.....	-0.005	4317.272	+0.180	+12.5	2
S 16.8567	4319.969	.....	-0.007	4319.762	+0.200	13.9	$\frac{1}{2}$
<i>Ti</i> 19.1827	4338.108	-0.024	.....	4338.084	.....	.....	.....
S 19.5305	4340.866	.....	-0.036	4340.634	+0.196	13.5	$\frac{1}{2}$
S 20.6401	4349.745	.....	-0.050	4349.541	+0.154	10.6	1
S 20.8818	4351.696	.....	-0.052	4351.495	+0.145	10.3	$\frac{1}{2}$
S 22.7898	4367.308	.....	-0.083	4367.012	+0.213	14.6	$\frac{1}{2}$
<i>Ti</i> 22.8641	4367.923	-0.084	.....	4367.839	.....	.....	.....
<i>Ti</i> 27.9241	4411.280	-0.040	.....	4411.240	.....	.....	.....
S 28.3726	4415.264	.....	-0.034	4415.076	+0.154	10.5	2
S 28.6063	4417.349	.....	-0.031	4417.121	+0.197	13.4	1
S 30.8757	4437.941	.....	+0.001	4437.718	+0.224	15.1	1
<i>Ti</i> 31.5267	4443.966	$\pm 0.010$	.....	4443.976	.....	.....	.....
<i>Ti</i> 34.1367	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 34.4710	4471.890	.....	+0.003	4471.676	+0.217	14.6	1
<i>Ti</i> 35.4497	4481.428	+0.010	.....	4481.438	.....	.....	.....
S 42.3849	4552.929	.....	+0.105	4552.750	+0.284	18.7	2
<i>Ti</i> 42.6262	4555.548	+0.114	.....	4555.662	.....	.....	.....
<i>Ti</i> 43.3830	4563.823	+0.116	.....	4563.939	.....	.....	.....
S 43.7684	4568.072	.....	+0.114	4567.950	+0.236	15.5	3
<i>Ti</i> 44.1265	4572.043	+0.113	.....	4572.156	.....	.....	.....
<i>Ti</i> 45.7245	4590.020	+0.106	.....	4590.126	.....	.....	.....
S 45.8308	4591.232	.....	+0.104	4591.066	+0.270	17.6	1
S 46.2829	4596.405	.....	+0.099	4596.291	+0.213	13.9	$\frac{1}{2}$
<i>Ti</i> 48.0837	4617.366	+0.086	.....	4617.452	.....	.....	.....
<i>Ti</i> 48.5765	4623.203	+0.076	.....	4623.279	.....	.....	.....
S 49.2176	4630.863	.....	+0.063	4630.703	+0.223	14.4	$\frac{1}{2}$
S 50.1463	4642.096	.....	+0.044	4641.886	+0.254	16.4	$\frac{1}{2}$
S 50.7505	4649.491	.....	+0.029	4649.250	+0.270	17.4	2
<i>Ti</i> 51.3287	4656.634	+0.010	.....	4656.644	.....	.....	.....
S 51.7620	4662.029	.....	+0.006	4661.728	+0.307	19.7	$\frac{1}{2}$
<i>Ti</i> 52.2197	Standard	$\pm 0.000$	.....	4667.768	.....	.....	.....

Curvature Cor.+0.0007 mm.

Weighted mean +14.7

Mean +14.6

 $V_a + 17.24$  $V_a + 0.01$ 

Reduction to Sun

+17.25

Radial Velocity

+32.0 km.

 $\beta$  CANIS MAJORIS — B 215Measured by F.  
Power 12

S 29.9290	4367.244	.....	$\pm 0.000$	4367.072	+0.172	+11.8	1
<i>Ti</i> 30.0008	Standard	$\pm 0.000$	.....	4367.839	.....	.....	.....
<i>Ti</i> 32.2802	4387.024	-0.017	.....	4387.007	.....	.....	.....
S 32.4325	4388.327	.....	-0.015	4388.100	+0.212	14.5	1
S 35.5175	4415.274	.....	-0.026	4415.076	+0.172	11.7	3
S 35.7475	4417.327	.....	-0.032	4417.121	+0.174	11.8	2
<i>Ti</i> 35.8135	4417.918	-0.034	.....	4417.884	.....	.....	.....
<i>Ti</i> 41.2755	4468.650	+0.013	.....	4468.663	.....	.....	.....
S 41.6092	4471.874	.....	+0.010	4471.676	+0.208	13.9	2
<i>Ti</i> 42.5900	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 42.5358	4481.498	.....	$\pm 0.000$	4481.400	+0.098	6.6	1
<i>Ti</i> 43.3042	4488.445	+0.048	.....	4488.493	.....	.....	.....
<i>Ti</i> 49.4875	4552.585	+0.047	.....	4552.632	.....	.....	.....
S 49.5212	4552.951	.....	+0.047	4552.750	+0.248	16.3	3
<i>Ti</i> 50.5230	4563.894	+0.045	.....	4563.939	.....	.....	.....
S 50.9108	4568.173	.....	+0.035	4567.950	+0.258	16.9	2
<i>Ti</i> 51.2672	4572.128	+0.028	.....	4572.156	.....	.....	.....

*$\beta$  CANIS MAJORIS B 215 Continued*

Mean of Settings	Wave-Length by Fusion	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 51.5355	4575.120	...	+0.023	4574.900	+0.243	+15.9	1 $\frac{1}{2}$
Ti 52.8655	Standard	$\pm 0.000$	...	4590.156	...	...	...
S 52.9748	4591.372	...	-0.002	4591.066	+0.304	19.8	1 $\frac{1}{2}$
S 53.4240	4596.518	...	-0.011	4596.291	+0.216	14.1	1
Ti 55.2248	4617.499	-0.047	...	4617.452	...	...	...

Curvature Cor.+0.0010 mm.

Weighted mean

+14.2

Mean +13.2

 $V_{cl}$  +17.24 $V_{cl}$  +0.01

Reduction to Sun +17.25

Radial Velocity +31.4 km.

SUMMARY OF MEASURES OF  *$\beta$  CANIS MAJORIS*

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 287	1901, Oct. 31	+33.5	15	+31.0	10
A 293	Nov. 1	...	...	+34.8	10
B 215	Nov. 7	+32.0	18	+31.4	11

Mean +32.8

+32.4

Mean of 3 plates +32.9 km.

Mean of all measures +32.6 km.

11.  *$\epsilon$  CANIS MAJORIS*(R. A.=6 $^{\circ}$  55 $^m$ ; Dec.= -28 $^{\circ}$  50'; Mag. 1.5; Class IIIa)

Three plates of this star have been measured, two by each observer. The spectrum is very similar to that of  *$\beta$  Canis Majoris*, but the oxygen and nitrogen lines are slightly more diffuse in character.

 *$\epsilon$  CANIS MAJORIS B 216*1901, November 7, G. M. T. 21 $^h$  51 $^m$   
Hour angle W. O. S.Measured by A. with Zeiss Comparator  
Power 20

Star good; comparison fair.

Mean of Settings	Wave Length by Fusion	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 64.9697	Standard	$\pm 0.000$	...	4338.084	...	...	...
S 64.9646	4345.798	...	-0.008	4345.677	+0.113	+7.8	2
S 67.7442	4349.754	...	-0.012	4349.541	+0.201	13.9	2
S 61.7808	4367.214	...	-0.030	4367.012	+0.162	11.1	1
Ti 61.2670	4367.869	-0.030	...	4367.839	...	...	...
S 58.8970	4388.247	...	-0.048	4388.100	+0.069	6.8	1
Ti 57.5415	4399.994	-0.059	...	4399.955	...	...	...
S 55.8782	4415.296	...	-0.062	4415.076	+0.098	6.7	2
S 55.5893	4417.311	...	-0.062	4417.121	+0.128	8.7	2
Ti 55.5158	4417.946	-0.062	...	4417.884	...	...	...
S 57.9280	4437.891	...	-0.014	4437.718	+0.159	10.7	2
Ti 52.6732	Standard	$\pm 0.000$	...	4443.976	...	...	...
Ti 50.0722	4468.663	-0.020	...	4468.664	...	...	...
S 49.7420	4471.896	...	-0.020	4471.676	+0.190	12.7	3
Ti 48.7676	4481.431	+0.007	...	4481.438	...	...	...
S 48.7740	4481.527	...	$\pm 0.007$	4481.400	+0.134	9.0	1
Ti 41.8927	4502.600	+0.032	...	4502.632	...	...	...
S 41.8903	4502.854	...	+0.032	4502.750	+0.136	9.0	1

$\epsilon$  CANIS MAJORIS—B 216—Continued

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 40.8585	4563.924	+0.015	.....	4563.939	.....	.....	.....
S 40.4787	4568.142	.....	+0.006	4567.950	+0.198	13.0	3
Ti 40.1182	4572.157	-0.001	.....	4572.156	.....	.....	.....
S 39.8528	4575.126	.....	-0.001	4574.900	+0.225	15.0	2
Ti 38.5281	Standard	$\pm 0.000$	.....	4580.126	.....	.....	.....
S 38.4293	4591.277	.....	$\pm 0.000$	4591.066	+0.211	13.8	1

Curvature Cor. -0.0009 mm.

Weighted mean

+11.0

Mean +10.6

 $V_a + 16.75$  $V_d - 0.01$ 

Reduction to Sun

+16.74

Radial Velocity

+27.7 km.

 $\epsilon$  CANIS MAJORIS—B 4511902, November 6, G. M. T. 21<sup>h</sup> 47<sup>m</sup>  
Hour angle 0<sup>h</sup> 0<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

Ti 20.2279	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 20.5550	4340.695	.....	-0.002	4340.634	+0.059	+ 4.1	2
S 21.1916	4345.819	.....	-0.006	4345.677	+0.136	9.4	1
Ti 23.8748	4367.863	-0.024	.....	4367.839	.....	.....	.....
S 26.2804	4388.287	.....	-0.016	4388.100	+0.171	11.7	2
Ti 27.0796	4395.215	-0.014	.....	4395.201	.....	.....	.....
Ti 27.6206	4399.947	-0.012	.....	4399.935	.....	.....	.....
S 29.3356	4415.173	.....	-0.021	4415.076	+0.076	5.2	2
S 29.5728	4417.306	.....	-0.022	4417.121	+0.163	11.1	2
Ti 29.6393	4417.906	-0.022	.....	4417.884	.....	.....	.....
Ti 30.6720	4427.282	-0.016	.....	4427.266	.....	.....	.....
S 31.8242	4437.899	.....	-0.008	4437.718	+0.173	11.7	2
S 32.8231	4447.239	.....	-0.002	4447.163	+0.074	5.0	1
Ti 33.0430	Standard	$\pm 0.000$	.....	4449.313	.....	.....	.....
Ti 35.0637	4468.662	+0.001	.....	4468.663	.....	.....	.....
S 35.3911	4471.849	.....	-0.001	4471.676	+0.172	11.5	2
Ti 36.3682	4481.446	-0.008	.....	4481.438	.....	.....	.....
S 36.3732	4481.495	.....	-0.008	4481.400	+0.087	5.8	2
Ti 43.2183	4552.610	+0.022	.....	4552.632	.....	.....	.....
S 43.2380	4552.825	.....	+0.022	4552.750	+0.086	6.3	2
Ti 44.2484	Standard	$\pm 0.000$	.....	4563.939	.....	.....	.....
S 44.6250	4568.124	.....	+0.003	4567.950	+0.177	11.6	2
Ti 44.9852	4572.149	+0.007	.....	4572.156	+0.139	9.1	2
S 45.2420	4575.032	.....	+0.007	4574.900	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted Mean

+ 8.4

Mean +8.2

 $V_a + 16.93$  $V_d - 0.00$ 

Reduction to Sun

+16.93

Radial Velocity

+25.3 km.

 $\epsilon$  CANIS MAJORIS—B 451Measured by F.  
Power 12

Ti 30.0044	4338.045	+0.039	.....	4338.084	.....	.....	.....
S 30.3391	4340.722	.....	+0.036	4340.634	+0.124	+ 8.6	1
S 33.5736	4367.188	.....	$\pm 0.000$	4367.012	+0.176	12.1	1 $\frac{1}{2}$
Ti 33.6515	Standard	$\pm 0.000$	.....	4367.839	.....	.....	.....
Ti 35.9161	4387.060	-0.053	.....	4387.007	.....	.....	.....
S 36.0505	4388.263	.....	-0.050	4388.100	+0.113	7.7	1 $\frac{1}{2}$

$\epsilon$  CANIS MAJORIS—B 451 *Continued*

Measure of Star Lines	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
$\mu$ m.	$\mu$ m.	$\mu$ m.	$\mu$ m.	$\mu$ m.	$\mu$ m.	km.	
<i>F</i> 37.3895	4399.950	-0.015	.....	4399.935	.....	.....	.....
<i>S</i> 39.1153	4415.186	.....	-0.024	4415.076	+0.086	+ 5.8	$1\frac{1}{2}$
<i>S</i> 39.4591	4417.298	.....	-0.025	4417.121	+0.152	10.3	1
<i>T</i> 39.4179	4417.909	-0.025	.....	4417.884	.....	.....	.....
<i>T</i> 41.8124	4468.667	-0.004	.....	4468.663	.....	.....	.....
<i>S</i> 45.1729	4471.874	.....	-0.003	4471.676	+0.195	13.1	2
<i>T</i> 46.1459	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
<i>T</i> 52.9675	4552.589	+0.043	.....	4552.632	.....	.....	.....
<i>S</i> 53.0178	4552.812	.....	+0.043	4552.750	+0.105	6.9	2
<i>T</i> 54.0282	4563.919	+0.020	.....	4563.939	.....	.....	.....
<i>S</i> 54.4653	4568.108	.....	-0.000	4567.950	+0.158	10.4	2
<i>T</i> 54.7696	4572.176	-0.020	.....	4572.156	.....	.....	.....
<i>S</i> 55.0261	4575.054	.....	-0.017	4574.900	+0.137	9.0	1
<i>T</i> 56.3537	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....
<i>S</i> 56.4464	4591.190	.....	-0.001	4591.066	+0.123	8.0	$1\frac{1}{2}$
<i>S</i> 56.8674	4596.386	.....	-0.006	4596.291	+0.089	5.8	.....
<i>T</i> 58.6974	4617.483	-0.031	.....	4617.452	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean + 9.2

M $\acute{e}$ an +8.9

$$\frac{V_a + 16.93}{V_d - 0.00}$$

Reduction to Sun +16.93

Radial Velocity +26.2 km.

 $\epsilon$  CANIS MAJORIS—B 4611902, November 19, G. M. T. 21<sup>h</sup> 0<sup>m</sup>

Hour angle W 0° 2'

Star fair; comparison fair.

Measured by F.  
Power 15

<i>T</i> 29.8020	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
<i>S</i> 33.3811	4367.283	.....	-0.048	4367.012	+0.223	+15.3	1
<i>T</i> 33.4534	4367.887	-0.048	.....	4367.839	.....	.....	.....
<i>T</i> 36.6624	4395.260	-0.059	.....	4395.201	.....	.....	.....
<i>T</i> 37.2046	4400.000	-0.065	.....	4399.935	.....	.....	.....
<i>S</i> 38.9310	4415.320	.....	-0.066	4415.076	+0.178	12.1	1
<i>S</i> 39.1565	4417.347	.....	-0.066	4417.121	+0.160	10.9	1
<i>T</i> 39.2234	4417.950	-0.066	.....	4417.884	.....	.....	.....
<i>T</i> 44.6513	4468.706	-0.043	.....	4468.663	.....	.....	.....
<i>S</i> 44.3806	4471.909	.....	-0.033	4471.676	+0.200	13.4	3
<i>T</i> 45.9516	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
<i>S</i> 45.9503	4481.623	.....	$\pm 0.000$	4481.400	+0.223	14.9	2
<i>T</i> 52.8063	4552.586	+0.046	.....	4552.632	.....	.....	.....
<i>S</i> 52.8402	4552.955	.....	+0.046	4552.750	+0.251	16.5	3
<i>T</i> 53.8438	4563.896	+0.043	.....	4563.939	.....	.....	.....
<i>S</i> 54.2231	4568.196	.....	+0.027	4567.950	+0.273	17.9	3
<i>T</i> 54.5769	4572.145	+0.011	.....	4572.156	.....	.....	.....
<i>S</i> 54.8412	4575.109	.....	+0.015	4574.900	+0.224	14.7	1
<i>T</i> 56.1825	4590.105	+0.021	.....	4590.126	.....	.....	.....
<i>S</i> 56.7174	4596.492	.....	+0.016	4596.291	+0.217	14.2	1
<i>T</i> 58.5092	Standard	$\pm 0.000$	.....	4617.452	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean +14.8

Mean +14.4

$$\frac{V_a + 14.74}{V_d - 0.00}$$

Reduction to Sun +14.74

Radial Velocity +29.6 km.

SUMMARY OF MEASURES OF  $\epsilon$  CANIS MAJORIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
B 216	1901, Nov. 7	+27.7	13	.....	..
B 451	1902, Nov. 6	+25.3	11	+26.2	11
B 461	Nov. 19	.....	..	+29.6	9
Mean		+26.5		+27.9	
		Mean of 3 plates +27.7 km.			
		Mean of all measures +27.2 km.			

12.  $\eta$  LEONIS(R. A. =  $10^h 2^m$ ; Dec. =  $+17^\circ 15'$ ; Mag. 3.6; Class VII<sup>e</sup>)

Three plates of this star have been measured, three by F., and two by A. The spectrum is well advanced toward the Ia2 type, the metallic lines being numerous and well defined. The helium line  $\lambda 4471$  is present but weak.

 $\eta$  LEONIS—B 329

1902, April 19, G. M. T.  $15^h 43^m$   
Hour angle W  $1^h 38^m$

Star good; comparison good.

Measured by A.  
Power 20

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 35.6462	4468.637	+0.026	.....	4468.663	.....	.....	.....
<i>S</i> 35.6874	4469.037	.....	+0.026	4468.663	+0.400	+26.8	1
<i>Ti</i> 36.9630	Standard	-0.000	.....	4481.438	.....	.....	.....
<i>S</i> 36.9634	4481.837	.....	+0.000	4481.400	+0.437	29.2	1
<i>Ti</i> 37.6612	4488.474	+0.019	.....	4488.493	.....	.....	.....
<i>S</i> 37.7913	4489.774	.....	+0.015	4489.331	+0.438	29.3	1
<i>S</i> 38.0125	4491.990	.....	+0.007	4491.570	+0.427	28.5	1
<i>Ti</i> 38.4433	4496.325	-0.007	.....	4496.318	.....	.....	.....
<i>S</i> 39.6756	4508.874	.....	+0.004	4508.455	+0.423	28.1	1
<i>Ti</i> 40.0663	4512.899	+0.007	.....	4512.906	.....	.....	.....
<i>S</i> 40.3610	4515.949	.....	+0.005	4515.508	+0.446	29.6	1
<i>S</i> 40.8270	4520.800	.....	+0.002	4520.397	+0.405	26.9	1
<i>Ti</i> 41.0349	Standard	$\pm 0.000$	.....	4522.974	.....	.....	.....
<i>Ti</i> 44.0855	4555.644	+0.018	.....	4555.662	.....	.....	.....
<i>S</i> 44.4158	4559.260	.....	+0.012	4558.827	+0.454	29.9	1
<i>Ti</i> 45.5779	4572.166	-0.010	.....	4572.156	.....	.....	.....
<i>S</i> 46.0019	4576.928	.....	-0.007	4576.512	+0.409	26.8	1
<i>S</i> 46.6666	4584.453	.....	-0.003	4584.018	+0.432	28.3	1
<i>S</i> 47.0507	4588.835	.....	-0.001	4588.381	+0.453	29.6	1
<i>Ti</i> 47.1634	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean +28.4

Mean +28.4

 $V_a = 25.98$  $V_d = 0.14$ 

Reduction to Sun -26.12

Radial Velocity +2.3 km.

 $\eta$  LEONIS—B 329

Measured by F.  
Power 18

<i>Ti</i> 29.0100	4344.347	+0.104	.....	4344.451	.....	.....	.....
<i>S</i> 29.9874	4352.275	.....	+0.088	4351.930	+0.433	+29.8	3
<i>Ti</i> 31.8642	4367.778	+0.061	.....	4367.839	.....	.....	.....
<i>S</i> 34.0068	4385.940	.....	+0.005	4385.548	+0.397	27.1	3
<i>Ti</i> 34.1306	4387.005	+0.002	.....	4387.007	.....	.....	.....
<i>Ti</i> 35.0730	4395.168	+0.033	.....	4395.201	.....	.....	.....

$\eta$  LEONIS B 329 Continued

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 35.1219	4395.594	.....	+0.008	4395.201	+0.401	+27.4	2
Ti 35.6180	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
S 37.5869	4417.445	.....	-0.038	4416.985	+0.422	28.6	4
Ti 37.6400	4417.923	-0.039	.....	4417.884	.....	.....	.....
Ti 40.4754	4443.981	-0.005	.....	4443.976	.....	.....	.....
S 40.5205	4444.404	.....	-0.005	4443.976	+0.423	28.5	1
Ti 42.7809	4465.979	-0.004	.....	4465.975	.....	.....	.....
Ti 43.0643	4468.666	-0.003	.....	4468.663	.....	.....	.....
S 43.1068	4469.069	.....	-0.004	4468.663	+0.402	27.0	1
Ti 43.3467	4471.413	-0.005	.....	4471.408	.....	.....	.....
Ti 44.3683	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 44.4067	4481.837	.....	$\pm 0.000$	4481.400	+0.437	29.2	4
Ti 45.0789	4488.497	-0.004	.....	4488.493	.....	.....	.....
S 45.2008	4489.804	.....	-0.003	4489.351	+0.450	30.0	11 $\frac{1}{2}$
S 45.4307	4492.016	.....	-0.001	4491.570	+0.445	29.7	2
Ti 45.8540	4496.316	+0.002	.....	4496.318	.....	.....	.....
Ti 46.3049	4501.450	-0.002	.....	4501.448	.....	.....	.....
S 46.4006	4501.813	.....	-0.002	4501.448	+0.363	24.2	2
S 47.0043	4508.903	.....	+0.004	4508.455	+0.452	30.1	4
Ti 47.4823	4512.899	+0.007	.....	4512.906	.....	.....	.....
S 47.7765	4515.943	.....	+0.006	4515.508	+0.441	29.3	3
Ti 47.9931	4518.193	+0.005	.....	4518.198	.....	.....	.....
S 48.2430	4520.798	.....	+0.008	4520.397	+0.409	27.1	3
Ti 48.4501	4522.903	+0.011	.....	4522.974	.....	.....	.....
S 48.4762	4523.236	.....	+0.011	4522.802	+0.445	29.5	3
Ti 48.8799	4527.478	+0.012	.....	4527.490	.....	.....	.....
Ti 50.5092	4544.849	+0.015	.....	4544.864	.....	.....	.....
S 50.9913	4550.069	.....	+0.018	4549.642	+0.445	29.3	3
Ti 51.2246	4552.608	+0.024	.....	4552.632	.....	.....	.....
Ti 51.5027	4555.646	+0.016	.....	4555.662	.....	.....	.....
S 51.5804	4556.497	.....	+0.020	4556.063	+0.454	29.9	21 $\frac{1}{2}$
S 51.8332	4559.272	.....	+0.020	4558.827	+0.465	30.6	2
Ti 52.2543	4563.919	+0.020	.....	4563.939	.....	.....	.....
S 52.2914	4564.330	.....	+0.020	4563.939	+0.411	27.0	1 $\frac{1}{2}$
Ti 52.9653	4572.166	-0.010	.....	4572.156	.....	.....	.....
S 53.0317	4572.573	.....	-0.010	4572.156	+0.407	27.7	1
S 54.0892	4584.474	.....	-0.004	4584.018	+0.452	29.6	3
S 54.4692	4588.831	.....	-0.001	4588.381	+0.449	29.3	1
Ti 54.5813	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0011 mm.

Weighted mean +28.8

Mean +28.6

 $V_a = -25.98$  $V_d = -0.14$ 

Reduction to Sun -26.12

Radial Velocity +2.7 km.

 $\eta$  LEONIS B 3331902, April 23, G. M. T. 15<sup>h</sup> 30<sup>m</sup>Hour angle W 1<sup>h</sup> 49<sup>m</sup>

Star excellent; comparison excellent.

Measured by F.

Power 17

Ti 27.5052	4367.774	+0.065	.....	4367.839	.....	.....	.....
S 29.6488	4385.944	.....	-0.004	4385.548	+0.392	+26.8	2
Ti 29.7739	4387.012	$\pm 0.005$	.....	4387.007	.....	.....	.....
S 30.7751	4395.695	.....	-0.001	4395.201	+0.493	33.6	1
Ti 31.2597	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
S 33.2344	4417.495	.....	-0.037	4416.985	+0.473	32.1	2
Ti 33.2817	4417.921	-0.037	.....	4417.884	.....	.....	.....
Ti 38.4304	4465.984	-0.009	.....	4465.975	.....	.....	.....
S 38.7612	4469.189	.....	-0.018	4468.663	+0.508	34.1	1
Ti 38.9617	4471.431	-0.023	.....	4471.408	.....	.....	.....
S 39.0608	4472.163	.....	-0.022	4471.676	+0.465	31.2	2
Ti 40.0117	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 40.0642	4481.838	.....	$\pm 0.000$	4481.400	+0.458	30.6	4

$\eta$  LEONIS B 333 *Continued*

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 40.7243	4488.514	-0.021	.....	4488.493	.....	.....	.....
S 40.8501	4489.770	.....	-0.021	4489.351	+0.398	26.6	1
<i>Ti</i> 41.0762	4492.034	.....	-0.021	4491.570	+0.443	29.6	2
<i>Ti</i> 41.5042	4496.339	-0.021	.....	4496.318	.....	.....	.....
S 42.7410	4508.927	.....	-0.019	4508.455	+0.453	30.1	3
<i>Ti</i> 43.1292	4512.924	-0.018	.....	4512.906	.....	.....	.....
S 43.4252	4515.987	.....	-0.013	4515.508	+0.466	31.0	2
<i>Ti</i> 43.6390	4518.207	-0.009	.....	4518.198	.....	.....	.....
S 43.8052	4520.876	.....	-0.010	4520.397	+0.469	31.1	2
<i>Ti</i> 44.0670	4522.985	-0.011	.....	4522.974	.....	.....	.....
S 44.1278	4523.308	.....	-0.011	4522.802	+0.495	32.8	2
S 45.9000	4542.106	.....	-0.009	4541.690	+0.407	26.9	1
<i>Ti</i> 46.1565	4544.867	-0.003	.....	4544.864	.....	.....	.....
S 46.6430	4550.132	.....	+0.002	4549.642	+0.492	32.4	4
<i>Ti</i> 46.8719	4552.623	+0.009	.....	4552.632	.....	.....	.....
<i>Ti</i> 47.1502	4555.662	$\pm 0.000$	.....	4555.662	.....	.....	.....
S 47.2269	4556.501	.....	+0.004	4556.063	+0.442	29.1	2
S 47.4772	4559.248	.....	+0.003	4558.827	+0.324	27.9	3
S 49.7345	4584.485	.....	+0.001	4584.018	+0.468	30.6	4
S 50.1154	4588.828	.....	$\pm 0.000$	4588.381	+0.447	29.2	1
<i>Ti</i> 50.2288	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0012 mm.

Weighted mean +30.4

Mean +30.3

 $V_a$  -26.84 $V_d$  -0.13

Reduction to Sun -26.97

Radial Velocity + 3.4 km.

 $\eta$  LEONIS—B 3371902. April 30, G. M. T. 15<sup>h</sup> 51<sup>m</sup>Hour angle W 2<sup>h</sup> 28<sup>m</sup>

Star weak; comparison good.

Measured by A.

Power 18

S 24.9032	4386.014	.....	$\pm 0.000$	4385.548	+0.466	+31.9	1
<i>Ti</i> 25.0188	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
S 28.4827	4417.468	.....	-0.031	4416.985	+0.452	30.7	1
<i>Ti</i> 28.5325	4417.916	-0.032	.....	4417.884	.....	.....	.....
<i>Ti</i> 31.3730	4443.980	-0.004	.....	4443.976	.....	.....	.....
S 31.4218	4444.437	.....	-0.004	4443.976	+0.457	30.8	1
<i>Ti</i> 35.2720	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 35.3186	4481.898	.....	$\pm 0.000$	4481.400	+0.498	33.3	1
<i>Ti</i> 36.0611	4489.268	-0.006	.....	4489.262	.....	.....	.....
S 36.1196	4489.852	.....	-0.006	4489.351	+0.495	33.1	1
S 38.0041	4508.922	.....	-0.008	4508.455	+0.459	30.5	1
<i>Ti</i> 38.3923	4512.914	-0.008	.....	4512.906	.....	.....	.....
S 38.6883	4515.973	.....	-0.006	4515.508	+0.459	30.5	1
S 39.1644	4520.920	.....	-0.002	4520.397	+0.521	34.6	1
<i>Ti</i> 39.3612	4522.975	-0.001	.....	4522.974	.....	.....	.....
S 41.1705	4542.141	.....	+0.005	4541.690	+0.456	30.1	1
<i>Ti</i> 41.4272	4544.858	+0.006	.....	4544.864	.....	.....	.....
<i>Ti</i> 42.4196	4555.669	-0.007	.....	4555.662	.....	.....	.....
S 42.4204	4555.678	.....	-0.007	4555.162	+0.509	33.5	1
S 42.5113	4556.672	.....	-0.007	4556.202	+0.463	30.5	1
S 44.3449	4577.015	.....	-0.003	4576.512	+0.500	32.8	1
S 44.9205	4583.515	.....	-0.001	4583.011	+0.503	32.9	1
S 45.0117	4584.550	.....	-0.001	4584.018	+0.531	34.7	1
S 45.3939	4588.904	.....	$\pm 0.000$	4588.381	+0.523	34.2	1
<i>Ti</i> 45.5008	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean +32.3

Mean +32.3

 $V_a$  -28.06 $V_d$  -0.20

Reduction to Sun -28.26

Radial Velocity + 4.0 km.

$\eta$  LEONIS - B 337Measured by F.  
Power 18

Mean. of Settings	Wave-length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	k. m.	
<i>Ti</i> 35.1895	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
S 35.2947	4481.884	.....	$\pm 0.000$	4481.400	+0.484	+32.4	.....
<i>Ti</i> 35.9777	4489.256	+0.006	.....	4489.262	.....	.....	.....
S 36.0361	4489.868	.....	+0.006	4489.951	+0.523	34.9	1
S 36.2548	4492.025	.....	+0.002	4491.570	+0.457	30.5	1½
<i>Ti</i> 36.6840	4496.336	-0.018	.....	4496.318	.....	.....	.....
<i>Ti</i> 37.4337	4503.928	-0.002	.....	4503.926	.....	.....	.....
S 37.9226	4508.924	.....	$\pm 0.000$	4508.455	+0.468	31.1	2
<i>Ti</i> 38.3063	4512.899	+0.007	.....	4512.906	.....	.....	.....
S 38.6383	4515.989	.....	+0.015	4515.508	+0.500	33.2	1½
<i>Ti</i> 38.8188	4518.171	+0.027	.....	4518.198	.....	.....	.....
S 39.0818	4520.908	.....	+0.016	4520.397	+0.527	35.0	2
<i>Ti</i> 39.2789	4522.966	+0.008	.....	4522.974	.....	.....	.....
S 39.3112	4523.303	.....	+0.008	4522.802	+0.509	33.8	3
<i>Ti</i> 39.7103	Standard	$\pm 0.000$	.....	4527.490	.....	.....	.....
S 41.0903	4542.155	.....	+0.019	4541.690	+0.484	32.0	1
<i>Ti</i> 41.3402	4544.841	+0.023	.....	4544.864	.....	.....	.....
S 41.8295	4550.152	.....	+0.021	4549.642	+0.510	33.6	1
<i>Ti</i> 42.0578	4552.613	+0.019	.....	4552.632	.....	.....	.....
<i>Ti</i> 42.3373	4555.662	$\pm 0.000$	.....	4555.662	.....	.....	.....
S 42.4250	4556.621	.....	+0.001	4556.063	+0.559	36.8	2
S 42.6712	4559.321	.....	+0.004	4558.827	+0.498	32.8	1
<i>Ti</i> 42.7418	4560.097	+0.005	.....	4560.102	.....	.....	.....
S 44.9904	4584.562	.....	+0.001	4584.018	+0.545	35.6	2½
S 45.2972	4588.855	.....	$\pm 0.000$	4588.381	+0.474	31.0	1
<i>Ti</i> 45.4183	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor.+0.0009 mm.

Weighted mean +33.5

Mean +33.3

 $V_a$  -28.06 $V_d$  0.20

Reduction to Sun -28.26

Radial Velocity +5.2 km.

SUMMARY OF MEASURES OF  $\eta$  LEONIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
B 329	1902, April 19	+2.3	11	+2.7	21
B 333	April 23	.....	.....	+3.4	18
B 337	April 30	+4.1	15	+5.2	13

Mean +3.2

+3.7

Mean of 3 plates +3.5 km.

Mean of all measures +3.5 km.

13.  $\gamma$  CORVI

(R. A. 12° 11' : Dec. 16° 59' : Mag. 2.8 : Class VIa)

Three plates of this star have been measured by each observer. The spectrum shows numerous very faint and broad metallic lines which are not adapted to accurate measurement. The *Mg* line  $\lambda$ 4481 is decidedly the best line in the spectrum.

1902, April 2, G. M. T. 16<sup>h</sup> 32<sup>m</sup>  
Hour angle E 0° 46<sup>m</sup>

$\gamma$  CORVI—B 305

Star fair; comparison good.

Measured by A.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 18.6801	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 18.9779	4340.465	.....	$\pm 0.000$	4340.634	-0.169	-11.7	1
<i>S</i> 30.9092	4443.870	.....	$\pm 0.000$	4443.976	-0.106	7.2	1
<i>Ti</i> 30.9205	Standard	$\pm 0.000$	.....	4443.976			
<i>S</i> 33.4950	4468.551	.....	-0.002	4468.663	-0.114	7.6	1
<i>Ti</i> 33.5067	4468.665	-0.002	.....	4468.663			
<i>S</i> 33.8066	4471.586	.....	-0.002	4471.676	-0.092	6.2	2
<i>S</i> 34.7998	4481.346	.....	-0.002	4481.400	-0.056	3.8	2
<i>Ti</i> 34.8093	4481.440	-0.002	.....	4481.438			
<i>S</i> 36.7853	4501.275	.....	+0.012	4501.445	-0.158	10.5	1
<i>Ti</i> 36.8008	4501.433	+0.012	.....	4501.445			
<i>S</i> 42.6707	4563.813	.....	$\pm 0.000$	4563.939	-0.126	8.3	2
<i>Ti</i> 42.6820	Standard	$\pm 0.000$	.....	4563.939			
<i>S</i> 43.4065	4572.054	.....	-0.038	4572.156	-0.140	9.2	2
<i>Ti</i> 43.4220	4572.194	-0.038	.....	4572.156			

Curvature Cor. +0.0008 mm.

Weighted mean

-7.7

Mean -8.0

$V_d - 1.09$

$V_d + 0.06$

Reduction to Sun

- 1.03

Radial Velocity

- 8.7 km.

$\gamma$  CORVI—B 305

Measured by F.  
Power 12

<i>S</i> 29.7935	4367.724	.....	$\pm 0.000$	4367.775	-0.051	-3.5	1
<i>Ti</i> 29.8072	Standard	$\pm 0.000$	.....	4367.839			
<i>Ti</i> 40.9655	4468.675	-0.012	.....	4468.663			
<i>S</i> 40.9687	4468.705	.....	-0.012	4468.663	+0.030	+ 2.0	1
<i>S</i> 41.0797	4469.494	.....	-0.014	4469.545	-0.065	- 4.4	2
<i>Ti</i> 41.2785	4471.430	-0.022	.....	4471.408			
<i>S</i> 41.3004	4471.644	.....	-0.022	4471.676	-0.054	- 3.6	1
<i>S</i> 42.2890	4481.356	.....	$\pm 0.000$	4481.400	-0.044	- 2.9	3
<i>Ti</i> 42.2973	Standard	$\pm 0.000$	.....	4481.438			
<i>Ti</i> 44.2900	4501.432	+0.013	.....	4501.445			
<i>S</i> 44.2935	4501.468	.....	+0.013	4501.445	+0.036	+ 2.4	1
<i>Ti</i> 45.9164	4518.177	+0.021	.....	4518.198			
<i>S</i> 45.9395	4518.418	.....	+0.021	4518.506	-0.067	- 4.4	1
<i>Ti</i> 48.8054	4548.909	+0.029	.....	4548.938			
<i>S</i> 48.8760	4549.677	.....	+0.029	4549.767	-0.061	- 4.0	2
<i>S</i> 50.1583	4563.758	.....	+0.020	4563.939	-0.161	-10.6	3
<i>Ti</i> 50.1730	4563.919	+0.020	.....	4563.939			
<i>Ti</i> 52.4960	Standard	$\pm 0.000$	.....	4590.126			

Weighted mean

-4.3

Mean -3.2

Curvature Cor.

-0.81

$V_d - 1.09$

$V_d + 0.06$

Reduction to Sun

-1.03

Radial Velocity

-6.2 km.

$\gamma$  CORVI—B 3121902, April 3, G. M. T. 16<sup>h</sup> 32<sup>m</sup>Hour angle E 0° 47<sup>m</sup>

Star rather weak; comparison good.

Measured by A.

Power 17

Mean of Settings	Wave-length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 21.3728	Standard	$\pm 0.000$	.....	4338.084			
S 21.6969			$\pm 0.000$	4340.634	-0.040	- 2.8	1
Ti 33.6225		+0.006	.....	4443.976			
S 36.2051			$\pm 0.000$	4468.663	-0.063	4.2	1
Ti 36.2116	Standard	$\pm 0.000$	.....	4468.663			
S 37.5626			+0.018	4481.400	-0.069	4.6	4
Ti 37.5134		+0.018	.....	4481.438			
S 42.6294			+0.027	4534.139	-0.134	8.9	2
Ti 42.6490		+0.027	.....	4534.139			
S 45.3798			+0.031	4563.939	-0.136	8.9	1
Ti 45.3921		+0.031	.....	4563.939			
S 46.1206			+0.017	4572.156	-0.112	7.3	2
Ti 46.1306		+0.017	.....	4572.156			
Ti 47.7164	Standard	$\pm 0.000$	.....	4590.126			

Curvature Cor. +0.0008 mm.

Weighted mean -6.1

Mean -6.1

 $V_{\text{st}} = 1.59$  $V_{\text{cl}} + 0.07$ 

Reduction to Sun -1.52

Radial Velocity -7.6 km.

 $\gamma$  CORVI—B 312

Measured by F.

Power 12

S 29.4604	4395.189	.....	+0.012	4395.286	-0.091	- 6.2	1
Ti 29.4610	4395.189	+0.012	.....	4395.201			
Ti 30.0634	Standard	$\pm 0.000$	.....	4399.935			
Ti 33.0530		-0.008	.....	4427.266			
S 33.0630			-0.008	4427.420	-0.017	- 1.2	1
Ti 34.8571		+0.009	.....	4443.976			
Ti 34.8623		+0.009	+0.009	4443.976	+0.049	+ 3.3	1
S 37.4455		+0.002	.....	4468.663			
S 37.4480		+0.002	+0.002	4468.663	+0.024	+ 1.6	1
S 38.7417		.....	$\pm 0.000$	4481.400	-0.036	- 2.4	3
Ti 38.7492	Standard	$\pm 0.000$	.....	4481.438			
Ti 40.7438		+0.001	.....	4501.445			
S 40.7570		+0.001	+0.001	4501.445	+0.133	+ 8.9	2
Ti 45.2619		+0.015	.....	4548.938			
S 45.3278		.....	+0.019	4549.767	-0.109	- 7.2	2
S 45.3644		.....	+0.029	4552.663	-0.125	- 8.2	1
Ti 45.0000		+0.029	.....	4552.632			
S 46.6158		.....	+0.023	4563.939	-0.146	- 9.6	1
Ti 46.6290		+0.023	.....	4563.939			
S 47.3905		.....	+0.016	4572.156	-0.076	- 5.0	1
Ti 47.3973		+0.016	.....	4572.156			
S 48.4139		+0.006	.....	4584.018	-0.057	- 3.7	1
Ti 48.9541	Standard	$\pm 0.000$	.....	4590.126			

Weighted mean -3.9

Mean -4.2

Curvature Cor. -0.87

 $V_{\text{st}} = -1.59$  $V_{\text{cl}} + 0.07$ 

Reduction to Sun -1.52

Radial Velocity -6.3 km.

1902, April 19, G. M. T. 17<sup>h</sup> 3<sup>m</sup>  
Hour angle W 0<sup>h</sup> 45<sup>m</sup>

 $\gamma$  CORVI—B 330

Star good; comparison good.

Measured by A.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 36.4469	4468.620	.....	$\pm 0.000$	4468.663	-0.043	-2.9	1
Ti 36.4513	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 37.7570	4481.457	.....	$\pm 0.003$	4481.400	+0.060	+4.9	2
Ti 37.7547	4481.435	$\pm 0.003$	.....	4481.438	.....	.....	.....
S 39.7493	4501.436	.....	$\pm 0.000$	4501.445	-0.009	-0.6	1
Ti 39.7504	Standard	$\pm 0.000$	.....	4501.445	.....	.....	.....
S 42.8979	4534.185	.....	-0.011	4534.139	+0.035	+2.3	1
Ti 42.9711	4534.964	-0.011	.....	4534.953	.....	.....	.....
S 45.6353	4563.896	.....	-0.002	4563.939	-0.045	-3.0	1
Ti 45.6394	4563.941	-0.002	.....	4563.939	.....	.....	.....
S 46.3747	4572.128	.....	$\pm 0.000$	4572.156	-0.028	-1.8	1
Ti 46.3772	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean +0.3

Mean -0.3

 $V_a$  -9.29 $V_d$  -0.06

Reduction to Sun -9.35

Radial Velocity -9.1 km.

 $\gamma$  CORVI—B 330

Measured by F.  
Power 12

Ti 30.0032	Standard	$\pm 0.000$	.....	4427.266	.....	.....	.....
S 30.0313	4427.523	.....	$\pm 0.000$	4427.420	+0.103	+7.0	1
Ti 34.4000	4468.667	-0.004	.....	4468.663	.....	.....	.....
S 34.4075	4468.739	.....	-0.004	4468.663	+0.072	4.8	$1\frac{1}{2}$
S 34.7232	4471.810	.....	-0.003	4471.676	+0.131	8.8	$1\frac{1}{2}$
Ti 35.7043	4481.439	-0.001	.....	4481.438	.....	.....	.....
S 35.7085	4481.490	.....	-0.001	4481.400	+0.089	6.0	3
Ti 37.7005	Standard	$\pm 0.000$	.....	4501.445	.....	.....	.....
S 37.7117	4501.558	.....	$\pm 0.000$	4501.445	+0.113	7.5	1
Ti 38.8196	4512.911	+0.001	.....	4512.912	.....	.....	.....
Ti 42.2250	4548.961	-0.023	.....	4548.938	.....	.....	.....
S 42.3124	4549.910	.....	-0.015	4549.767	+0.128	8.4	1
Ti 42.5618	4552.625	+0.007	.....	4552.632	.....	.....	.....
Ti 43.5924	4563.950	-0.011	.....	4563.939	.....	.....	.....
S 43.5985	4564.028	.....	-0.011	4563.939	+0.078	5.1	1
Ti 44.3295	Standard	$\pm 0.000$	.....	4572.156	.....	.....	.....
S 44.3304	4572.166	.....	$\pm 0.000$	4572.156	+0.010	0.7	1

Weighted mean +5.9

Mean +6.0

Curvature Cor. -0.86

 $V_a$  -9.29 $V_d$  -0.06

Reduction to Sun -9.35

Radial Velocity -4.3 km.

SUMMARY OF MEASURES OF  $\gamma$  CORVI

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
B 305	1902, April 2	-8.7	8	-6.2	9
B 312	April 3	-7.6	6	-6.3	10
B 330	April 19	-9.1	6	-4.3	8

Mean -8.4 -5.5

Mean of 3 plates -7.0 km.

Mean of all measures -7.0 km.

14.  $\tau$  HERCULIS(R. A. =  $16^{\text{h}} 17^{\text{m}}$ ; Dec. =  $+46^{\circ} 33'$ ; Mag. 3.9; Class Va)

Four plates of this star have been measured, four by A., and two by F. The spectrum is very similar to that of  $\beta$  Orionis, the lines being rather broad but fairly well defined.

1902, February 19, G. M. T.  $21^{\text{h}} 33^{\text{m}}$   
Hour angle E  $2^{\circ} 33'$

 $\tau$  HERCULIS—A 325

Star good; comparison good.

Measured by A.  
Power 20

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 21.1914	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 21.3245	4340.276	.....	$\pm 0.000$	4340.634	-0.358	-24.7	2
S 25.6210	4387.718	.....	$\pm 0.000$	4388.100	-0.382	26.1	2
Ti 26.2596	Standard	$\pm 0.000$	.....	4395.201	.....	.....	.....
Ti 32.1604	4468.667	-0.004	.....	4468.663	.....	.....	.....
S 32.3572	4471.260	.....	-0.003	4471.676	-0.419	28.1	4
S 33.0975	4481.103	.....	$\pm 0.000$	4481.400	-0.297	19.9	2
Ti 33.1225	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....

Curvature Cor.  $+0.0005$  mm.

Weighted mean ..... -25.4

Mean -24.7

 $V_a + 11.77$  $V_d + 0.15$ Reduction to Sun .....  $+11.92$ 

Radial Velocity ..... -13.5 km.

 $\tau$  HERCULIS—B 295

Star good; comparison good.

Measured by A.  
Power 21

1902, March 12, G. M. T.  $22^{\text{h}} 9^{\text{m}}$   
Hour angle E  $0^{\circ} 45'$

Ti 21.2628	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 21.5607	4340.383	.....	$\pm 0.000$	4340.634	-0.253	-17.5	1
Ti 27.1712	4387.026	-0.019	.....	4387.007	.....	.....	.....
S 27.2620	4387.808	.....	-0.018	4388.100	-0.310	21.2	2
Ti 28.6561	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
Ti 28.6928	4468.650	$+0.013$	.....	4468.663	.....	.....	.....
S 36.3713	4471.362	.....	$+0.010$	4471.676	-0.303	20.3	3
S 37.3580	4481.064	.....	$\pm 0.000$	4481.400	-0.336	22.5	4
Ti 37.3958	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....

Curvature Cor.  $+0.0009$  mm.

Weighted mean ..... -21.1

Mean -20.4

 $V_a + 9.65$  $V_d + 0.05$ Reduction to Sun .....  $+ 9.70$ 

Radial Velocity ..... -11.4 km.

 $\tau$  HERCULIS—B 301

Star slightly weak; comparison good.

Measured by A.  
Power 20

1902, March 13, G. M. T.  $19^{\text{h}} 36^{\text{m}}$   
Hour angle E  $3^{\circ} 12'$

Ti 29.1733	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
S 33.3228	4437.190	.....	$\pm 0.000$	4437.718	-0.258	-17.4	1
Ti 34.0320	Standard	$\pm 0.000$	.....	4443.976	.....	.....	.....
Ti 36.0224	4468.968	-0.005	.....	4468.663	.....	.....	.....
S 36.3031	4471.397	.....	-0.001	4471.676	-0.283	19.0	3
S 37.3874	4481.051	.....	$\pm 0.000$	4481.400	-0.349	23.4	3
Ti 37.9296	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....

Curvature Cor.  $+0.0008$  mm.

Weighted mean ..... -20.6

Mean -19.9

 $V_a + 9.53$  $V_d + 0.17$ Reduction to Sun .....  $+ 9.70$ 

Radial Velocity ..... -10.9 km.

$\tau$  HERCULIS—B 301Measured by F.  
Power 14

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 36.1373	Standard	$\pm 0.000$	.....	4465.975			
<i>S</i> 36.6877	4471.332	.....	+0.003	4471.676	-0.341	-22.9	1
<i>Ti</i> 36.6851	4471.405	+0.003	.....	4471.408			
<i>S</i> 37.6728	4481.014	.....	$\pm 0.000$	4481.400	-0.386	-25.8	1
<i>Ti</i> 37.7157	Standard	$\pm 0.000$	.....	4481.438			
<i>Ti</i> 38.4255	Standard	$\pm 0.000$	.....	4488.493			

Curvature Cor. +0.0013 mm.

Weighted mean

-24.4

Mean -24.4

 $V_a + 9.53$  $V_d + 0.17$ 

Reduction to Sun + 9.70

Radial Velocity -14.7 km.

 $\tau$  HERCULIS—B 313Measured by A.  
Power 171902, April 8, G. M. T. 17<sup>h</sup> 29<sup>m</sup>Hour angle E 3<sup>h</sup> 58<sup>m</sup>

Star weak; comparison fair.

<i>Ti</i> 21.1901	Standard	$\pm 0.000$	.....	4338.084			
<i>S</i> 21.4742	4340.354	.....	-0.001	4340.634	-0.281	-19.4	1
<i>S</i> 27.2043	4387.939	.....	-0.026	4388.100	-0.187	12.8	1
<i>Ti</i> 28.0459	4395.231	-0.030	.....	4395.201			
<i>S</i> 32.7402	4437.439	.....	-0.004	4437.718	-0.283	19.1	2
<i>Ti</i> 33.4414	Standard	$\pm 0.000$	.....	4443.976			
<i>Ti</i> 36.0305	4468.668	-0.005	.....	4468.663			
<i>S</i> 36.3129	4471.415	.....	-0.002	4471.676	-0.263	17.6	3
<i>S</i> 37.2987	4481.091	.....	+0.012	4481.400	-0.297	20.0	4
<i>Ti</i> 37.3326	4481.426	+0.012	.....	4481.438			
<i>Ti</i> 45.2153	Standard	$\pm 0.000$	.....	4563.939			

Curvature Cor. +0.0008 mm.

Weighted mean

-18.5

Mean -17.8

 $V_a + 6.17$  $V_d + 0.20$ 

Reduction to Sun + 6.37

Radial Velocity -12.1 km.

 $\tau$  HERCULIS—B 313Measured by F.  
Power 12

<i>Ti</i> 39.1607	Standard	$\pm 0.000$	.....	4468.663			
<i>S</i> 39.4455	4471.439	.....	$\pm 0.000$	4471.676	-0.237	-15.9	1
<i>S</i> 40.4213	4481.032	.....	$\pm 0.000$	4481.400	-0.368	-24.6	1
<i>Ti</i> 40.4623	Standard	$\pm 0.000$	.....	4481.438			
<i>Ti</i> 48.3471	4563.949	-0.010	.....	4563.939			
<i>Ti</i> 49.0852	Standard	$\pm 0.000$	.....	4572.156			

Curvature Cor. +0.0013 mm.

Weighted mean

-20.3

Mean -20.3

 $V_a + 6.17$  $V_d + 0.20$ 

Reduction to Sun + 6.37

Radial Velocity -13.9 km.

SUMMARY OF MEASURES OF  $\tau$  HERCULIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 325	1902, Feb. 19	-13.5	4	.....	..
B 295	Mar. 12	-11.4	4	.....	..
B 301	Mar. 13	-10.9	3	-14.7	2
B 313	April 3	-12.1	5	-13.9	2

Mean -12.0 -14.3

Mean of 4 plates -12.7 km.

Mean of all measures -12.7 km.

15.  $\zeta$  DRACONIS

(R. A. =  $17^h 7^m$ ; Dec. =  $+65^\circ 50'$ ; Mag. 3.3; Class Va)

Four plates of this star have been measured, by each observer. The spectrum contains few lines, but these, though rather broad, are better defined than in most of the stars containing them.

 $\zeta$  DRACONIS — B 290

1902, February 3, G. M. T. 22<sup>h</sup> 24<sup>m</sup>  
Hour angle E  $3^h 42^m$

Star good; comparison rather weak.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 20.6686	Standard	$\pm 0.000$	.....	4338.084			
S 20.9577	4340.406	.....	$\pm 0.000$	4340.634	-0.228	-15.8	1
S 22.3687	4351.863	.....	$\pm 0.000$	4352.083	-0.220	15.2	1
Ti 28.0210	Standard	$\pm 0.000$	.....	4389.935			
S 29.9143	4416.863	.....	-0.003	4417.121	-0.261	17.7	1
Ti 30.0273	4417.887	.....	-0.003	4417.884			
Ti 35.4213	4468.674	-0.011	.....	4468.663			
S 35.7115	4471.517	.....	-0.008	4471.676	-0.167	11.2	1
S 36.6858	4481.146	.....	$\pm 0.000$	4481.400	-0.254	17.0	3
Ti 36.7152	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor. +0.0008 mm.

Weighted mean -15.8

Mean -15.4

$V_a + 2.03$

$V_d + 0.12$

Reduction to Sun + 2.15

Radial Velocity -13.7 km.

 $\zeta$  DRACONIS — B 290

Measured by F.  
Power 12

Ti 35.0010	Standard	$\pm 0.000$	.....	4338.084			
S 35.3010	4340.406	.....	-0.001	4340.634	-0.139	-9.6	2
Ti 42.3545	Standard	$\pm 0.000$	.....	4389.935			
Ti 49.7540	4468.659	$\pm 0.001$	.....	4468.663			
S 50.0357	4471.417	.....	$\pm 0.003$	4471.676	-0.256	17.2	2
S 51.0149	4481.080	.....	$\pm 0.000$	4481.400	-0.323	21.4	3
Ti 51.0500	Standard	$\pm 0.000$	.....	4481.438			

Curvature Cor. +0.0010 mm.

Weighted mean -16.5

Mean -16.1

$V_a + 2.03$

$V_d + 0.12$

Reduction to Sun + 2.15

Radial Velocity -14.4

1902, February 10, G. M. T. 22<sup>h</sup> 12<sup>m</sup>  
Hour angle E 3<sup>h</sup> 24<sup>m</sup>

§ DRACONIS — A 314

Star good; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 21.4626	Standard	± 0.000	.....	4338.084	.....	.....	.....
<i>S</i> 21.6748	4340.375	.....	± 0.000	4340.634	-0.259	-17.9	3
<i>Ti</i> 25.8323	4387.016	-0.009	.....	4387.007	.....	.....	.....
<i>S</i> 25.9032	4387.842	.....	-0.009	4388.100	-0.267	18.2	2
<i>Ti</i> 26.9314	Standard	± 0.000	.....	4399.935	.....	.....	.....
<i>Ti</i> 32.4327	4468.671	-0.008	.....	4468.663	.....	.....	.....
<i>S</i> 32.6389	4471.388	.....	-0.006	4471.676	-0.294	19.7	3
<i>S</i> 33.3751	4481.177	.....	± 0.000	4481.400	-0.223	14.9	3
<i>Ti</i> 33.3946	Standard	± 0.000	.....	4481.438	.....	.....	.....

Curvature Cor. +0.0005 mm.

Weighted mean

-17.7

Mean -17.7

$$V_a + 1.79$$

$$V_d + 0.11$$

Reduction to Sun

+ 1.90

Radial Velocity

-15.8 km.

§ DRACONIS — A 314

Measured by F.  
Power 12

<i>Ti</i> 34.9934	Standard	± 0.000	.....	4338.084	.....	.....	.....
<i>S</i> 35.2065	4340.365	.....	± 0.000	4340.644	-0.269	-18.6	2
<i>Ti</i> 39.3611	4387.004	+0.003	.....	4387.007	.....	.....	.....
<i>S</i> 39.4230	4387.717	.....	+0.003	4388.100	-0.380	26.0	1/2
<i>Ti</i> 40.4611	Standard	± 0.000	.....	4399.935	.....	.....	.....
<i>Ti</i> 45.7584	4466.003	.....	.....	4465.975	.....	.....	.....
<i>S</i> 46.1762	4471.499	+0.028	.....	4471.676	-0.159	10.7	2
<i>S</i> 46.9095	4481.252	.....	+0.018	4471.676	-0.148	9.9	2
<i>Ti</i> 46.9234	Standard	± 0.000	.....	4481.400	.....	.....	.....
		.....	.....	4481.438	.....	.....	.....

Curvature Cor. +0.0009 mm.

Weighted mean

-14.0

Mean -16.3

$$V_a + 1.79$$

$$V_d + 0.11$$

Reduction to Sun

+ 1.90

Radial Velocity

-12.2 km.

§ DRACONIS — A 324

1901, February 19, G. M. T. 20<sup>h</sup> 33<sup>m</sup>  
Hour angle E 4<sup>h</sup> 33<sup>m</sup>

Star good; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 22.5708	Standard	± 0.000	.....	4338.084	.....	.....	.....
<i>S</i> 22.7874	4340.422	.....	-0.001	4340.634	-0.213	-14.7	3
<i>Ti</i> 26.9425	4387.027	-0.020	.....	4387.007	.....	.....	.....
<i>S</i> 27.0189	4387.916	.....	-0.020	4388.100	-0.204	13.9	1
<i>Ti</i> 28.0410	Standard	± 0.000	.....	4399.935	.....	.....	.....
<i>Ti</i> 33.5441	4468.669	-0.006	.....	4468.663	.....	.....	.....
<i>S</i> 33.7545	4471.441	.....	-0.005	4471.676	-0.240	16.1	4
<i>S</i> 34.4909	4481.229	.....	± 0.000	4481.400	-0.171	11.4	1
<i>Ti</i> 34.5065	Standard	± 0.000	.....	4481.438	.....	.....	.....

Curvature Cor. +0.0005 mm.

Weighted Mean

-14.9

Mean -14.0

$$V_a + 1.44$$

$$V_d + 0.13$$

Reduction to Sun

+ 1.57

Radial Velocity

-13.3 km.

## ♄ DRACONIS — A 324

Measured by F.  
Power 12

Mean of Settings	Wave Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
$T_1$ 34.9984	Standard	+0.000	.....	4338.084			
$S_1$ 45.7107	4340.570		+0.000	4340.634	-0.264	-18.2	2
$T_2$ 40.4686	Standard	+0.000	.....	4399.935			
$T_3$ 45.9704	4468.650	+0.007	.....	4468.663			
$S_3$ 46.1808	4471.442		-0.006	4471.676	-0.240	16.1	1 $\frac{1}{2}$
$S_3$ 46.9134	4481.185		$\pm 0.000$	4481.400	-0.215	14.4	2
$T_4$ 46.9321	Standard	+0.000	.....	4481.438			

Curvature Cor. = 0.0009 mm.

Weighted mean

-16.2

Mean -16.2

$$V_d + 1.44$$

$$V_d + 0.13$$

Reduction to Sun

+ 1.60

Radial Velocity

-14.6 km.

## ♄ DRACONIS — B 357

Measured by A  
Power 21POE, May 30, G. M. T. 16<sup>h</sup> 4<sup>m</sup>Hour angle 1<sup>h</sup> 2<sup>m</sup> 27<sup>s</sup>

Star fair; comparison good.

$T_1$ 34.9984	Standard	+0.000		4338.084			
$S_1$ 45.7106	4340.460		+0.000	4340.634	-0.234	-16.2	1
$S_1$ 45.7485	4341.848		-0.002	4352.083	-0.207	14.3	1
$T_2$ 40.4686	4397.843	+0.001		4397.839			
$T_2$ 48.6601	Standard	+0.000		4399.935			
$S_2$ 49.6791	4479.918		+0.025	4417.121	-0.189	12.8	2
$T_3$ 46.6853	4471.070	+0.026		4417.884			
$T_3$ 46.1518	4468.014	+0.041		4468.663			
$S_3$ 46.1857	4471.476		-0.008	4471.676	-0.208	14.0	3
$S_3$ 46.4104	4481.185		+0.000	4481.400	-0.214	14.3	2
$T_4$ 46.4388	Standard	+0.000	.....	4481.438			

Curvature Cor. = 0.0008 mm.

Weighted mean

-14.0

Mean -14.3

$$V_d - 2.46$$

$$V_d - 0.09$$

Reduction to Sun

- 2.87

Radial Velocity

-16.4 km.

## ♄ DRACONIS — B 357

Measured by F.  
Power 12

$T_1$ 34.9984	Standard	+0.000		4338.084			
$S_1$ 45.7106	4340.460		+0.000	4340.634	-0.22	-16.2	2
$S_1$ 45.7485	4341.848		-0.002	4352.083	-0.17	-3.4	1
$T_2$ 40.4686	4397.843	+0.001		4397.839			
$T_2$ 48.6601	Standard	+0.000		4399.935			
$S_2$ 49.6791	4479.918		+0.025	4417.121	-0.17	-15.2	3
$T_3$ 46.6853	4471.070	+0.026		4417.884			
$T_3$ 46.1518	4468.014	+0.041		4468.663			
$S_3$ 46.1857	4471.476		-0.008	4471.676	-0.17	-15.2	3
$S_3$ 46.4104	4481.185		+0.000	4481.400	-0.17	-15.2	3
$T_4$ 46.4388	Standard	+0.000	.....	4481.438			

Curvature Cor. = 0.0009 mm.

Weighted mean

-14.7

Mean -10.6

$$V_d - 1.46$$

$$V_d - 0.09$$

Reduction to Sun

- 1.65

Radial Velocity

-11.4 km.

SUMMARY OF MEASURES OF  $\epsilon$  DRACONIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
B 290	1902, Feb. 3	-13.7	5	-14.4	3
A 314	Feb. 10	-15.8	4	-12.2	4
A 324	Feb. 19	-13.3	4	-14.6	3
B 357	May 30	-16.4	5	-15.1	4

Mean -14.8 -14.1

Mean of 4 plates -14.4 km.

Mean of all measures -14.4 km.

16.  $\epsilon$  HERCULIS

(R. A.  $17^h 37^m$ ; Dec.  $+46^\circ 4'$ ; Mag. 3.9; Class IV b)

Five plates of this star have been measured, two by F., and four by A. The spectrum contains few lines, but these are well defined, and suitable for fairly accurate measurement.

 $\epsilon$  HERCULIS - A 251

1901, September 27, G. M. T. 14<sup>h</sup> 35<sup>m</sup>  
 Filter, blue W 3-30

Star good; comparison strong.

Measured by A.  
 Power 21

Wavelength	Wave Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
4320	4386.904	+0.013		4387.007			
4314	4387.961		+0.012	4388.100	-0.127	-8.7	1
4318	Standard	$\pm 0.000$		4389.935			
4360	4437.582		+0.012	4437.718	-0.124	8.4	1
7 31.3001	4443.962	+0.014		4443.976			
4377	4465.975	$\pm 0.000$		4465.975			
4379	4471.573		$\pm 0.000$	4471.676	-0.103	6.9	3
4387	4481.277		$\pm 0.000$	4481.400	-0.123	8.2	4
4390	Standard	$\pm 0.000$		4481.438			
4392	4552.574		+0.044	4552.750	-0.132	8.7	1
4392	4552.588	+0.044		4552.632			
4497	4563.950	-0.011		4563.939			
4449	4567.871		-0.010	4567.950	-0.089	5.8	2
7 31.8944	Standard	$\pm 0.000$		4590.126			

Curvature Cor. +0.0001 mm.

Weighted mean - 7.6

Mean -7.8

$$\begin{aligned} V_a &= 10.06 \\ V_d &= 0.19 \end{aligned}$$

Reduction to Sun 10.25

Radial Velocity -17.8 km.

 $\epsilon$  HERCULIS - A 260

1901, October 3, G. M. T. 15<sup>h</sup> 30<sup>m</sup>  
 Filter, blue W 4-45

Star good; comparison fair.

Measured by A.  
 Power 21

Wavelength	Wave Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
7 17.2714	4387.020	-0.013		4387.007			
7 17.3044	4387.974		-0.012	4388.100	-0.138	-9.4	1
4389	Standard	$\pm 0.000$		4389.935			
4390	4427.319	-0.053		4427.266			
4396	4437.651		-0.043	4437.718	-0.110	7.4	1
8 24.1877	4471.587		-0.009	4471.676	-0.098	6.6	2
8 24.9277	4481.286		$\pm 0.000$	4481.400	-0.114	7.6	2
4490	Standard	$\pm 0.000$		4481.438			
7 30.0724	4552.642	-0.010		4552.632			
8 30.0713	4552.616		0.010	4552.750	-0.134	8.8	1
7 30.2792	Standard	$\pm 0.000$		4555.662			

Curvature Cor. +0.0001 mm.

Weighted mean -7.8

Mean -8.0

$$\begin{aligned} V_a &= 9.71 \\ V_d &= 0.22 \end{aligned}$$

Reduction to Sun - 9.93

Radial Velocity -17.7 km.

## HERCULIS—A 260

Measured by F.  
Power 12

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	μ. m.	μ. m.	μ. m.	μ. m.	μ. m.	km.	
Ti 30.0003	Standard	±0.000	.....	4338.084	.....	.....	.....
S 30.2400	4340.645	.....	-0.001	4340.634	+0.010	+0.7	1
Ti 34.4350	4387.038	-0.031	.....	4387.007	.....	.....	.....
S 34.5245	4388.065	.....	-0.030	4388.100	-0.065	-4.4	3
Ti 35.5491	4399.945	-0.010	.....	4399.935	.....	.....	.....
Ti 37.8363	Standard	±0.000	.....	4427.266	.....	.....	.....
S 38.6818	4437.656	.....	+0.009	4437.718	-0.053	-3.6	2
Ti 39.1885	4443.961	+0.015	.....	4443.976	.....	.....	.....
Ti 40.9215	4465.976	-0.001	.....	4465.975	.....	.....	.....
S 41.3537	4471.579	.....	+0.006	4471.676	-0.091	-6.1	4
S 42.0020	4481.255	.....	+0.019	4481.400	-0.126	-8.4	4
Ti 42.1044	4481.419	+0.019	.....	4481.438	.....	.....	.....
Ti 47.4434	Standard	±0.000	.....	4555.662	.....	.....	.....

Weighted mean                    5.6  
 Curvature Cor.                - 0.27  
 $V_{st}$                     -9.71  
 $V_{st}$                     -0.22  
 Reduction to Sun               - 9.93  
 Radial Velocity                -15.8 km.

Mean -4.4

1901, October 18, G. M. T. 15<sup>h</sup> 27<sup>m</sup>  
Hour angle W 5<sup>h</sup> 42<sup>m</sup>

## HERCULIS—B 203

Star weak; comparison strong.

Measured by A.  
Power 24

Ti 40.3344	Standard	±0.000	.....	4468.663	.....	.....	.....
S 40.6326	4471.547	.....	+0.001	4471.676	-0.128	-8.6	1
S 41.6345	4481.279	.....	+0.005	4481.400	-0.116	7.8	2
Ti 41.6502	4481.433	+0.005	.....	4481.438	.....	.....	.....
Ti 44.7949	4512.903	+0.003	.....	4512.906	.....	.....	.....
Ti 48.5741	4552.617	+0.015	.....	4552.632	.....	.....	.....
S 48.5752	4552.629	.....	+0.015	4552.750	-0.106	7.0	2
Ti 51.9644	Standard	±0.000	.....	4590.126	.....	.....	.....
Ti 61.7980	Standard	±0.000	.....	4710.368	.....	.....	.....
S 62.0145	4713.227	.....	±0.000	4713.308	-0.081	5.2	3

Curvature Cor. +0.0002 mm.

Weighted mean                    - 6.7  
 $V_{st}$                     -8.39  
 $V_{st}$                     -0.24  
 Reduction to Sun               = 8.63  
 Radial Velocity                -15.3 km.

Mean -7.1

## HERCULIS—B 203

Measured by F.  
Power 12

Ti 34.9675	4386.971	+0.036	.....	4387.007	.....	.....	.....
S 35.1125	4387.952	.....	+0.033	4388.100	-0.115	- 7.9	2
Ti 36.5035	Standard	±0.000	.....	4399.935	.....	.....	.....
Ti 37.7940	4411.248	-0.008	.....	4411.240	.....	.....	.....
S 38.2660	4414.927	.....	-0.009	4415.076	-0.158	10.7	1 <sub>2</sub>
Ti 43.7450	4465.969	-0.024	.....	4465.975	.....	.....	.....
S 44.3220	4471.555	.....	-0.015	4471.676	-0.136	9.1	3
S 45.3240	4481.282	.....	±0.000	4481.400	-0.118	7.9	4
Ti 45.3400	Standard	±0.000	.....	4481.438	.....	.....	.....

*HERCULIS—B 203—Continued*

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 52.2650	4552.612	+0.020	.....	4552.632			
S 52.2660	4552.622	.....	+0.020	4552.750	-0.108	-7.1	2
Ti 55.6550	Standard	+0.000	.....	4590.126			
Ti 61.2750	4656.666	-0.022	.....	4656.644			
Ti 65.4895	4710.502	-0.134	.....	4710.368			
S 65.7060	4713.366	.....	-0.146	4713.308	-0.088	5.6	3

Weighted mean  $\bar{V}_a = 7.6$       Mean  $-8.0$   
 Curvature Cor.  $\bar{V}_d = 0.18$   
 $\bar{V}_a - 8.39$   
 $\bar{V}_d - 0.24$   
 Reduction to Sun  $= 8.63$   
 Radial Velocity  $-16.4$  km.

*HERCULIS—B 403*

1902, September 3, G. M. T. 17<sup>h</sup> 20<sup>m</sup>  
 Hour angle W 4<sup>h</sup> 38<sup>m</sup>

Star good; comparison good.

Measured by A.  
 Power 17

Ti 20.9299	Standard	$\pm 0.000$	.....	4338.084			
S 21.2447	4340.589	.....	-0.002	4340.634	-0.047	-3.3	1
Ti 26.8642	4387.044	-0.037	.....	4387.007			
S 26.9867	4388.095	.....	-0.035	4388.100	-0.040	2.7	3
Ti 28.3553	4399.953	-0.018	.....	4399.935			
Ti 31.4156	4427.263	+0.003	.....	4427.266			
S 32.5444	4437.625	.....	+0.002	4437.718	-0.091	6.2	2
Ti 33.7972	Standard	$\pm 0.000$	.....	4449.313			
Ti 35.8235	4468.651	+0.012	.....	4468.663			
S 36.1231	4471.557	.....	+0.019	4471.676	-0.100	6.7	3
S 37.1156	4481.271	.....	+0.043	4481.400	-0.086	5.8	4
Ti 37.1282	4481.395	+0.043	.....	4481.438			
Ti 44.0047	Standard	$\pm 0.000$	.....	4552.632			
S 44.0054	4552.640	.....	$\pm 0.000$	4552.750	-0.110	7.2	3

Curvature Cor.  $+0.0008$  mm.      Weighted mean  $\bar{V}_a = 5.5$       Mean  $-5.3$   
 $\bar{V}_d = 0.22$   
 Reduction to Sun  $= 10.58$   
 Radial Velocity  $-16.1$  km.

SUMMARY OF MEASURES OF *HERCULIS*

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 251	1901, Sept. 27	-17.8	6	.....	..
A 260	Oct. 3	-17.7	5	-15.8	5
B 203	Oct. 18	-15.3	4	-16.4	6
B 403	1902, Sept. 3	-16.1	6	.....	..

Mean  $-16.7$        $-16.1$   
 Mean of 4 plates  $-16.6$  km.  
 Mean of all measures  $-16.4$  km.

## 17. 67 OPHIUCHI

(R. A.  $-17^{\text{h}} 56^{\text{m}}$ ; Dec.  $= +2^{\circ} 56'$ ; Mag. 4.0; Class Vc)

Three plates of this star have been measured, three by A., and one by F. The lines present in the spectrum are few in number and rather diffuse in character.

## 67 OPHIUCHI—B 347

1902, May 14, G. M. T. 19<sup>h</sup> 14<sup>m</sup>  
Hour angle E 1<sup>h</sup> 7<sup>m</sup>

Star weak; comparison strong.

Measured by A.  
Power 17

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
m $\mu$	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 26.5243	Standard	$\pm 0.000$	.....	4387.007			
S 26.6119	4387.761		$\pm 0.000$	4388.100	-0.339	-23.2	2
Ti 35.1864	4465.985	-0.010	.....	4465.975			
S 35.1506	4471.458		-0.007	4471.676	-0.225	15.1	2
S 36.7347	4481.107		$\pm 0.000$	4481.400	-0.293	19.6	1
Ti 36.7682	Standard	$\pm 0.000$	.....	4481.438			
S 43.6078	4552.378		+0.017	4552.750	-0.355	23.4	2
Ti 43.6295	4552.615	+0.017	.....	4552.632			
S 46.4528	4583.798		$\pm 0.000$	4584.018	-0.220	14.4	1
Ti 46.9877	Standard	$\pm 0.000$	.....	4590.126			

Curvature Cor.  $+0.0008$  mm.Weighted mean  $-19.6$ Mean  $-19.1$  $V_a +15.51$  $V_d +0.10$ Reduction to Sun  $+15.61$ Radial Velocity  $-4.0$  km.

## 67 OPHIUCHI—B 369

1902, June 25, G. M. T. 19<sup>h</sup> 41<sup>m</sup>  
Hour angle W 2<sup>h</sup> 11<sup>m</sup>

Star weak; comparison fair.

Measured by A.  
Power 15

Ti 33.5001	Standard	$\pm 0.000$	.....	4465.975			
S 34.1816	4471.703		$\pm 0.000$	4471.676	+0.027	+1.8	1
S 35.1712	4481.334		+0.002	4481.400	-0.007	-0.5	3
Ti 35.1757	4481.436	+0.002	.....	4481.438			
Ti 39.2903	Standard	$\pm 0.000$	.....	4522.974			
Ti 42.0514	4552.621	+0.011	.....	4552.632			
S 42.0688	4552.702		+0.011	4552.750	-0.037	-2.4	2
Ti 45.4160	Standard	$\pm 0.000$	.....	4590.126			

Curvature Cor.  $+0.0008$  mm.Weighted mean  $-0.7$ Mean  $-0.4$  $V_a -2.19$  $V_d -0.18$ Reduction to Sun  $-2.37$ Radial Velocity  $-3.1$  km.

1902, July 7, G. M. T. 17<sup>h</sup> 32<sup>m</sup>  
Hour angle W 1<sup>h</sup> 45<sup>m</sup>

67 *OPHIUCHI*—A 346

Star good; comparison good.

Measured by A.  
Power 15

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
S 27.0710	4388.094	.....	± 0.000	4388.100	—0.006	—0.4	2
<i>Ti</i> 28.0857	Standard	± 0.000	.....	4399.935			
<i>Ti</i> 33.6391	4468.668	—0.005	.....	4468.663			
S 33.8791	4471.798	.....	—0.005	4471.676	+0.117	+7.8	3
<i>Ti</i> 34.6120	4481.441	—0.003	.....	4481.438			
S 34.6180	4481.521	.....	—0.003	4481.400	+0.113	+7.9	4
<i>Ti</i> 37.9791	Standard	± 0.000	.....	4527.490			
S 41.2400	4575.018	.....	± 0.000	4574.900	+0.118	+7.7	1
<i>Ti</i> 47.8867	Standard	± 0.000	.....	4682.088			
<i>Ti</i> 49.5012	4710.417	—0.049	.....	4710.368			
S 49.6696	4713.429	.....	—0.049	4713.308	+0.072	+4.6	4

Curvature Cor. +0.0005 mm.

Weighted mean +5.7

Mean +5.5

$$\begin{array}{r} V_a \quad 7.38 \\ V_d \quad 0.15 \end{array}$$

Reduction to Sun — 7.53

Radial Velocity — 1.8 km.

67 *OPHIUCHI*—A 346

Measured by F. with Zeiss Comparator  
Power 13

<i>Ti</i> 32.491	4337.977	+0.107	.....	4338.084			
S 36.978	4388.069	.....	+0.020	4388.100	—0.011	—0.8	2
<i>Ti</i> 37.992	Standard	± 0.000	.....	4399.935			
<i>Ti</i> 43.320	4466.002	—0.027	.....	4465.975			
S 43.760	4471.765	.....	—0.017	4471.676	+0.072	+4.8	3
<i>Ti</i> 44.493	Standard	± 0.000	.....	4481.438			
S 44.494	4481.451	.....	± 0.000	4481.400	+0.051	+3.4	4
<i>Ti</i> 45.600	4496.329	—0.011	.....	4496.318			
<i>Ti</i> 49.587	Standard	± 0.000	.....	4552.432			
S 49.594	4552.735	.....	± 0.000	4552.750	—0.015	—1.0	1 <sub>2</sub>

Weighted mean +2.5

Mean +1.6

Curvature Cor. +1.41

$$\begin{array}{r} V_a \quad -7.38 \\ V_d \quad -0.15 \end{array}$$

Reduction to Sun — 7.53

Radial Velocity — 3.6 km.

SUMMARY OF MEASURES OF 67 *OPHIUCHI*

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
B 347	1902, May 14	—4.0	5	.....	..
B 369	June 25	—3.1	3	.....	..
A 346	July 7	—1.8	5	—3.6	4

Mean —3.0

—3.6

Mean of 3 plates —3.3 km.

Mean of all measures —3.1 km.

18. 102 *HERCULIS*(R. A.  $+18^{\circ} 4^m$ ; Dec.  $+20^{\circ} 48'$ ; Mag. 4.5; Class IVb)

Four plates of this star have been measured, four by A., and one by F. The lines in the spectrum are diffuse, and not well adapted to accurate measurement.

1902, July 23, G. M. T. 17<sup>h</sup> 53<sup>m</sup> 102 *HERCULIS*—A 358  
Hour angle W 2<sup>h</sup> 0<sup>m</sup> Star good; comparison fair. Measured by A.  
Power 13

Meas. of Spect.	Wave Length, m. Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
T <sub>1</sub> 21.0816	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
S 25.5551	.....	.....	-0.015	4388.100	-0.062	-4.2	2
T <sub>1</sub> 26.1014	.....	-0.017	.....	4385.201	.....	.....	.....
T <sub>1</sub> 28.8035	.....	-0.016	.....	4427.266	.....	.....	.....
S 29.7168	.....	.....	-0.006	4437.718	+0.030	+2.0	1
T <sub>1</sub> 30.2141	Standard	$\pm 0.000$	.....	4443.976	.....	.....	.....
T <sub>1</sub> 32.1335	.....	$\pm 0.050$	.....	4468.663	.....	.....	.....
S 32.3930	.....	.....	+0.049	4471.676	-0.045	-3.0	2
T <sub>1</sub> 38.2196	.....	+0.031	.....	4552.632	.....	.....	.....
S 38.2291	.....	.....	+0.031	4552.750	+0.022	+1.4	1
T <sub>1</sub> 38.9877	Standard	$\pm 0.000$	.....	4563.939	.....	.....	.....
S 39.2907	.....	.....	$\pm 0.000$	4567.950	+0.061	+4.0	1

Curvature Cor.  $+0.0005$  mm.Weighted mean  $-1.0$ 

Mean 0.0

 $V_d = 10.13$  $V_d = 0.16$ Reduction to Sun  $10.29$ Radial Velocity  $-11.3$  km.

1902, August 11, G. M. T. 16<sup>h</sup> 12<sup>m</sup> 102 *HERCULIS*—B 385  
Hour angle W 1<sup>h</sup> 35<sup>m</sup> Star good; comparison good. Measured by A.  
Power 15

T <sub>1</sub> 21.1940	Standard	$\pm 0.000$	.....	4338.084	.....	.....	.....
T <sub>1</sub> 27.1297	.....	-0.045	.....	4387.007	.....	.....	.....
S 27.2596	.....	.....	-0.044	4388.100	+0.023	+1.6	1
T <sub>1</sub> 28.8223	.....	-0.036	.....	4389.935	.....	.....	.....
S 30.5551	.....	.....	-0.029	4417.121	+0.120	8.2	1
T <sub>1</sub> 30.6177	.....	-0.029	.....	4417.884	.....	.....	.....
T <sub>1</sub> 31.9828	.....	-0.006	.....	4427.266	.....	.....	.....
S 32.8320	.....	.....	-0.003	4437.718	+0.104	7.0	1
T <sub>1</sub> 34.0647	Standard	$\pm 0.000$	.....	4449.313	.....	.....	.....
T <sub>1</sub> 36.3638	.....	-0.002	.....	4468.663	.....	.....	.....
S 36.4078	.....	.....	-0.002	4471.676	+0.030	2.0	2
S 37.1010	.....	.....	-0.001	4481.400	+0.023	1.5	1
T <sub>1</sub> 37.0025	.....	-0.001	.....	4481.438	.....	.....	.....
T <sub>1</sub> 46.2533	.....	$\pm 0.020$	.....	4552.632	.....	.....	.....
S 46.2930	.....	.....	+0.020	4552.750	+0.040	2.6	2
T <sub>1</sub> 46.3132	Standard	$\pm 0.000$	.....	4563.939	.....	.....	.....

Curvature Cor.  $+0.0009$  mm.Weighted mean  $+3.5$ Mean  $+3.8$  $V_d = 15.36$  $V_d = 0.13$ Reduction to Sun  $15.49$ Radial Velocity  $-12.0$  km.

## 102 HERCULIS—B 385

Measured by F.  
Power 13

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 30.0027	4337.991	+0.093	.....	4338.084	.....	.....	.....
<i>S</i> 30.3396	4340.675	.....	+0.088	4340.634	+0.129	+8.9	1
<i>Ti</i> 35.9388	Standard	±0.000	.....	4387.007	.....	.....	.....
<i>S</i> 36.0675	4388.112	.....	±0.000	4388.100	+0.012	+0.8	2
<i>Ti</i> 37.4313	4389.933	+0.002	.....	4389.935	.....	.....	.....
<i>Ti</i> 40.4935	4427.266	±0.000	.....	4427.266	.....	.....	.....
<i>S</i> 41.6344	4437.739	.....	+0.002	4437.718	+0.023	+1.6	1
<i>Ti</i> 42.8747	4449.300	+0.004	.....	4449.313	.....	.....	.....
<i>Ti</i> 45.1844	4471.387	+0.021	.....	4471.408	.....	.....	.....
<i>S</i> 45.2204	4471.736	.....	+0.021	4471.676	+0.081	+5.4	2
<i>Ti</i> 46.2120	Standard	±0.000	.....	4481.438	.....	.....	.....
<i>S</i> 46.2134	4481.452	.....	±0.000	4481.400	+0.052	+3.5	2
<i>Ti</i> 53.0896	4552.611	+0.021	.....	4552.632	.....	.....	.....
<i>S</i> 53.1003	4552.727	.....	+0.021	4552.750	-0.002	-0.1	3
<i>Ti</i> 56.4554	Standard	±0.000	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean

+2.7

Mean +3.3

$$\begin{aligned} V_a & -15.36 \\ V_d & 0.13 \end{aligned}$$

Reduction to Sun

-15.49

Radial Velocity

-12.8 km.

## 102 HERCULIS—B 397

1902, August 27, G. M. T. 15<sup>h</sup> 0<sup>m</sup>  
Hour angle W 1<sup>h</sup> 28<sup>m</sup>

Star too weak; comparison strong.

Measured by A.  
Power 15

<i>Ti</i> 23.4054	4387.005	+0.002	.....	4387.007	.....	.....	.....
<i>S</i> 23.6159	4388.297	.....	+0.002	4388.100	+0.199	+13.6	2
<i>Ti</i> 24.9590	Standard	±0.000	.....	4399.935	.....	.....	.....
<i>Ti</i> 28.0223	4427.263	+0.003	.....	4427.266	.....	.....	.....
<i>Ti</i> 32.4369	4468.681	-0.018	.....	4468.663	.....	.....	.....
<i>S</i> 32.7593	4471.805	.....	-0.014	4471.676	+0.115	7.7	3
<i>Ti</i> 33.7445	Standard	±0.000	.....	4481.438	.....	.....	.....
<i>S</i> 33.7507	4481.499	.....	±0.000	4481.400	+0.099	6.6	2
<i>Ti</i> 40.6291	4552.634	-0.002	.....	4552.632	.....	.....	.....
<i>S</i> 40.6590	4552.937	.....	-0.002	4552.750	+0.185	12.2	2
<i>Ti</i> 41.6619	Standard	±0.000	.....	4563.939	.....	.....	.....
<i>S</i> 42.0462	4568.189	.....	-0.020	4567.950	+0.219	14.4	1
<i>Ti</i> 42.4064	4572.195	-0.039	.....	4572.156	.....	.....	.....

Curvature Cor. +0.0009 mm.

Weighted mean

+10.3

Mean +10.9

$$\begin{aligned} V_a & -18.64 \\ V_d & 0.12 \end{aligned}$$

Reduction to Sun

-18.76

Radial Velocity

- 8.5 km.

## 102 HERCULIS—B 402

1902, September 3, G. M. T. 15<sup>h</sup> 10<sup>m</sup>  
Hour angle W 2<sup>h</sup> 0<sup>m</sup>

Star rather weak; comparison strong.

Measured by A.  
Power 17

<i>Ti</i> 21.1240	Standard	±0.000	.....	4338.084	.....	.....	.....
<i>Ti</i> 27.0559	4387.056	-0.049	.....	4387.007	.....	.....	.....
<i>S</i> 27.1998	4388.291	.....	-0.049	4388.100	+0.142	+ 9.7	1
<i>Ti</i> 28.5484	4399.982	-0.047	.....	4399.935	.....	.....	.....
<i>Ti</i> 29.8296	4411.283	-0.043	.....	4411.240	.....	.....	.....
<i>S</i> 30.2799	4415.300	.....	-0.043	4415.076	+0.181	12.3	2
<i>Ti</i> 30.5728	4417.927	-0.043	.....	4417.884	.....	.....	.....
<i>Ti</i> 31.6073	4427.286	-0.020	.....	4427.266	.....	.....	.....
<i>S</i> 32.7566	4437.839	.....	-0.007	4437.718	+0.114	7.7	2

## 102 HERCULIS—B 402—Continued

Means of Settings	Wave Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave Length	Displacement	Velocity	Weight
m $\mu$ .	$\mu$ m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 33 4167	4443.975	+0.001	.....	4443.976	.....	.....	.....
Ti 36 0140	Standard	$\pm 0.000$	.....	4468.663	.....	.....	.....
S 34 3404	4471.829	.....	-0.001	4471.676	+0.152	10.2	3
Ti 37 3224	4481.441	-0.003	.....	4481.438	.....	.....	.....
S 37 3290	4481.506	.....	-0.003	4481.400	+0.103	6.9	2
Ti 44 1950	4552.603	+0.029	.....	4552.632	.....	.....	.....
S 44 2215	4552.891	.....	+0.029	4552.750	+0.170	11.2	2
Ti 45 2240	4563.905	+0.034	.....	4563.939	.....	.....	.....
S 45 0087	4568.151	.....	+0.014	4567.950	+0.215	14.1	3
Ti 45 0603	4572.161	-0.005	.....	4572.156	.....	.....	.....
S 46 2301	4575.079	.....	-0.004	4574.900	+0.175	11.5	2
Ti 47 5587	Standard	$\pm 0.000$	.....	4590.126	.....	.....	.....

Curvature Cor. +0.0008 mm.

Weighted mean

+10.6

Mean +10.4

 $V_a$  -19.65 $V_d$  - 0.16

Reduction to Sun -19.81

Radial Velocity - 9.2 km.

## SUMMARY OF MEASURES OF 102 HERCULIS

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 358	1902, July 23	-11.3	5	.....	.....
B 385	Aug. 11	-12.0	6	-12.8	6
B 397	Aug. 27	- 8.5	5	.....	.....
B 402	Sept. 3	- 9.2	8	.....	..

Mean -10.3

-12.8

Mean of 4 plates -10.4 km.

Mean of all measures -10.8 km.

19.  $\eta$  LYRAE(R.A. = 19<sup>h</sup> 10<sup>m</sup>; Dec. = +38° 58'; Mag. 4.5; Class IVb)

Four plates of this star have been measured, four by A., and two by F. The spectrum contains but few lines, and these are not very sharply defined, so that accurate measurement is difficult.

1902, July 31, G. M. T. 20<sup>h</sup> 51<sup>m</sup> $\eta$  LYRAE—A 365Hour angle W 4<sup>h</sup> 21<sup>m</sup>

Star fair; comparison good.

Measured by A.  
Power 21

S 27 4020	4388.029	.....	$\pm 0.000$	4388.100	-0.071	-4.9	1
Ti 28 5143	Standard	$\pm 0.000$	.....	4389.935	.....	.....	.....
Ti 30 7621	4427.273	-0.007	.....	4427.296	.....	.....	.....
S 31 6288	4437.606	.....	-0.004	4437.718	-0.116	7.8	2
Ti 32 5612	Standard	$\pm 0.000$	.....	4449.313	.....	.....	.....
Ti 34 0605	4468.601	-0.028	.....	4468.663	.....	.....	.....
S 34 2915	4471.500	.....	-0.022	4471.676	-0.108	7.2	2
S 35 0255	4481.264	.....	$\pm 0.000$	4481.400	-0.136	9.1	3
Ti 35 0386	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....

Curvature Cor. +0.0005 mm.

Weighted mean

- 7.8

Mean -7.3

 $V_a$  -2.45 $V_d$  -0.24

Reduction to Sun - 2.69

Radial Velocity -10.5 km.

1902, September 13, G. M. T. 17<sup>h</sup> 57<sup>m</sup>  
Hour angle W 4<sup>h</sup> 20<sup>m</sup>

$\eta$  LYRAE — B 409

Star weak; comparison good.

Measured by A.  
Power 15

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 22.4473	4387.014	−0.007	.....	4387.007	.....	.....	.....
S 22.5690	4388.060	.....	−0.006	4388.100	−0.046	−3.1	2
<i>Ti</i> 23.9362	Standard	±0.000	.....	4399.935	.....	.....	.....
S 25.8703	4417.103	.....	+0.001	4417.121	−0.017	−1.2	1
<i>Ti</i> 25.9569	4417.883	+0.001	.....	4417.884	.....	.....	.....
<i>Ti</i> 26.9923	4427.268	−0.002	.....	4427.266	.....	.....	.....
S 28.1365	4437.793	.....	−0.004	4437.718	+0.071	+4.8	3
<i>Ti</i> 28.8010	4443.981	−0.005	.....	4443.976	.....	.....	.....
<i>Ti</i> 31.1153	Standard	±0.000	.....	4465.975	.....	.....	.....
S 31.7046	4471.688	.....	+0.003	4471.676	+0.015	+1.0	3
<i>Ti</i> 32.6982	4481.429	+0.009	.....	4481.438	.....	.....	.....
S 32.6941	4481.388	.....	+0.009	4481.400	−0.003	−0.2	3
<i>Ti</i> 39.5651	Standard	±0.000	.....	4552.632	.....	.....	.....
S 39.5829	4552.826	.....	±0.000	4552.750	+0.076	+5.0	1

Curvature Cor. +0.0008 mm.

Weighted mean + 1.1

Mean +1.1

$$\begin{aligned} V_a &= -11.51 \\ V_d &= -0.24 \end{aligned}$$

Reduction to Sun −11.75

Radial Velocity −10.6 km.

1902, October 15, G. M. T. 14<sup>h</sup> 12<sup>m</sup>  
Hour angle W 2<sup>h</sup> 45<sup>m</sup>

$\eta$  LYRAE — B 422

Star fair; comparison good.

Measured by A.  
Power 21

<i>Ti</i> 29.6491	Standard	±0.000	.....	4338.084	.....	.....	.....
S 29.9775	4340.698	.....	±0.000	4340.634	+0.064	+4.4	1
S 35.7220	4388.258	.....	±0.000	4388.100	+0.158	10.8	2
<i>Ti</i> 36.5256	Standard	±0.000	.....	4395.201	.....	.....	.....
<i>Ti</i> 40.1270	4427.253	+0.013	.....	4427.266	.....	.....	.....
S 41.2721	4437.777	.....	+0.009	4437.718	+0.068	4.6	1
<i>Ti</i> 41.9376	4443.969	+0.007	.....	4443.976	.....	.....	.....
<i>Ti</i> 44.5326	4468.669	−0.006	.....	4468.663	.....	.....	.....
S 44.8526	4471.778	.....	−0.004	4471.676	+0.098	6.6	1
<i>Ti</i> 45.8379	Standard	±0.000	.....	4481.438	.....	.....	.....
S 45.8425	4481.483	.....	±0.000	4481.400	+0.083	5.6	3

Curvature Cor. +0.0009 mm.

Weighted mean + 6.7

Mean +6.4

$$\begin{aligned} V_a &= -14.54 \\ V_d &= -0.17 \end{aligned}$$

Reduction to Sun −14.71

Radial Velocity −8.0 km.

$\eta$  LYRAE — B 422

Measured by F.  
Power 13

<i>Ti</i> 30.0739	Standard	±0.000	.....	4338.084	.....	.....	.....
S 30.4100	4340.762	.....	−0.002	4340.634	+0.126	+8.7	1 <sub>2</sub>
S 36.1563	4388.376	.....	−0.036	4388.100	+0.240	16.4	2
<i>Ti</i> 36.9505	4395.241	−0.040	.....	4395.201	.....	.....	.....
<i>Ti</i> 44.9578	4468.686	−0.023	.....	4468.663	.....	.....	.....
S 45.2926	4471.936	.....	−0.017	4471.676	+0.243	16.3	3
<i>Ti</i> 46.2628	Standard	±0.000	.....	4481.438	.....	.....	.....
S 46.2719	4481.528	.....	±0.000	4481.400	+0.128	8.6	3
<i>Ti</i> 54.1648	Standard	±0.000	.....	4563.939	.....	.....	.....
S 54.5322	4568.011	.....	−0.010	4567.950	+0.051	3.4	1
<i>Ti</i> 54.9059	4572.176	−0.020	.....	4572.156	.....	.....	.....

Curvature Cor. +0.0013 mm.

Weighted mean +12.1

Mean +10.7

$$\begin{aligned} V_a &= -14.54 \\ V_d &= -0.17 \end{aligned}$$

Reduction to Sun −14.71

Radial Velocity −2.6 km.

1902, October 16, G. M. T. 15<sup>h</sup> 32<sup>m</sup>  
Hour angle W 4° 23'

$\eta$  LYRAE B 427

Star weak; comparison good.

Measured by A.  
Power 21

Mean of Settings	Wave-Length by Formula	Correction to Comp. Lines	Correction to Star Lines	Normal Wave-Length	Displacement	Velocity	Weight
mm.	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
<i>Ti</i> 25.6843	4386.989	+0.018	.....	4387.007	.....	.....	.....
<i>S</i> 25.8232	4388.183	.....	+0.016	4388.100	+0.099	+ 6.8	2
<i>Ti</i> 27.1756	Standard	$\pm 0.000$	.....	4399.935	.....	.....	.....
<i>Ti</i> 30.2336	4427.297	-0.031	.....	4427.266	.....	.....	.....
<i>S</i> 31.3788	4437.837	.....	-0.020	4437.718	+0.099	6.7	2
<i>Ti</i> 32.0390	4443.989	-0.013	.....	4443.976	.....	.....	.....
<i>Ti</i> 34.6291	4468.668	-0.005	.....	4468.663	.....	.....	.....
<i>S</i> 35.9322	4481.424	.....	$\pm 0.000$	4481.400	+0.024	1.6	3
<i>Ti</i> 35.9336	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
<i>Ti</i> 42.7896	4552.595	+0.037	.....	4552.632	.....	.....	.....
<i>S</i> 42.8125	4552.845	.....	+0.037	4552.750	+0.132	8.7	1
<i>Ti</i> 43.8220	Standard	$\pm 0.000$	.....	4563.939	.....	.....	.....
<i>S</i> 44.1927	4568.055	.....	$\pm 0.000$	4567.950	+0.105	6.9	2

Curvature Cor. + 0.008 mm.

Weighted mean + 5.4

Mean + 6.1

$V_a$  -14.57

$V_d$  - 0.24

Reduction to Sun -14.81

Radial Velocity - 9.4 km.

$\eta$  LYRAE B 427

Measured by F.  
Power 13

<i>Ti</i> 30.0406	Standard	$\pm 0.000$	.....	4387.007	.....	.....	.....
<i>S</i> 31.1635	4388.062	.....	+0.000	4388.100	-0.038	- 2.6	1
<i>Ti</i> 34.5896	Standard	$\pm 0.000$	.....	4427.266	.....	.....	.....
<i>S</i> 35.7360	4437.817	.....	-0.003	4437.718	+0.096	+ 6.5	1
<i>Ti</i> 36.9653	4449.320	-0.007	.....	4449.313	.....	.....	.....
<i>Ti</i> 39.2676	4471.412	0.004	.....	4471.408	.....	.....	.....
<i>S</i> 39.3137	4471.861	.....	-0.004	4471.676	+0.181	+12.1	3
<i>Ti</i> 40.2880	Standard	$\pm 0.000$	.....	4481.438	.....	.....	.....
<i>S</i> 40.2929	4481.487	.....	$\pm 0.000$	4481.400	+0.087	+ 5.8	3

Curvature Cor. + 0.0013 mm.

Weighted mean + 7.2

Mean + 5.5

$V_a$  -14.57

$V_d$  - 0.24

Reduction to Sun -14.81

Radial Velocity - 7.6 km.

#### SUMMARY OF MEASURES OF $\eta$ LYRAE

Plate	Date	Adams	No. of Lines	Frost	No. of Lines
A 265	1902, July 31	-10.5	4	.....	.....
B 409	Sept. 13	-10.6	6	.....	.....
B 122	Oct. 15	- 8.0	5	-2.6	5
B 427	Oct. 16	- 9.4	5	-7.6	4

Mean - 9.6 -5.1

Mean of 4 plates -8.7 km.

Mean of all measures -9.1 km.

#### 20. $\epsilon$ DELPHINI

(R. A. = 20<sup>h</sup> 28<sup>m</sup>; Dec. = +10° 58'; Mag. 4.1; Class Va)

Four plates of this star have been measured, all of them by A. The spectrum contains very few lines, among them traces of one or two oxygen lines, and all of these are poorly defined.

1922, July 11, G. M. T. 17<sup>h</sup> 55<sup>m</sup>  
Hour angle E 3° 11'

## + DELPHINI - A 309

Star fixed; comparison fixed.

Measured by A.  
Power 14

Mean of Surfaces	True Image of Primary	Comparison in Cross Lines	Comparison in Star Lines	Corrected Star Position	Displacement	Parallax	Measure
$T_1$ 25 56.0	Standard	$\pm 0.000$	—	448.084	—	—	—
$S_1$ 25 56.2	4480.002	—	$\pm 0.000$	448.084	—	—	—
$T_2$ 25 57.0	Standard	$\pm 0.000$	—	448.084	$-0.007$	$-41.4$	1
$S_2$ 25 57.3	4477.708	—	$\pm 0.000$	448.084	—	—	—
$T_3$ 31 24.0	4478.000	$\pm 0.000$	—	448.080	$-0.009$	$-41.4$	1
$S_3$ 31 24.0	4477.004	—	$\pm 0.000$	448.080	—	—	—
$S_4$ 31 31.2	4480.800	—	$\pm 0.000$	448.080	$-0.004$	$-39.7$	2
$T_4$ 32 01.0	Standard	$\pm 0.000$	—	448.080	$-0.006$	$-39.9$	2

Curvature  $C_{\text{star}} = 0.000$  mm.

Weighted mean

-38.2

Mean -37.7

$$T_{\text{mean}} = -40.25$$

$$T_{\text{star}} = -41.30$$

Reduction to Sun

-40.65

Radial Velocity

-27.8 km.

1922, July 16, G. M. T. 18<sup>h</sup> 48<sup>m</sup>  
Hour angle W 0° 3'

## + DELPHINI - A 309

Star fixed; comparison fixed.

Measured by A.  
Power 17

Mean of Surfaces	True Image of Primary	Comparison in Cross Lines	Comparison in Star Lines	Corrected Star Position	Displacement	Parallax	Measure
$T_1$ 25 57.0	Standard	$\pm 0.000$	—	448.084	—	—	—
$S_1$ 25 58.0	4480.000	—	$\pm 0.000$	448.084	—	—	—
$T_2$ 25 58.0	4480.200	$-0.008$	—	448.084	$-0.045$	$-39.8$	1
$T_3$ 25 59.0	Standard	$\pm 0.000$	—	448.082	—	—	—
$T_4$ 30 00.0	4478.000	$-0.008$	—	448.080	—	—	—
$S_2$ 30 23.8	4477.100	—	$\pm 0.000$	447.075	$-0.004$	$-37.1$	2
$S_3$ 30 37.0	4480.002	—	$\pm 0.000$	448.080	$-0.004$	$-39.4$	2
$T_5$ 31 00.0	Standard	$\pm 0.000$	—	448.080	—	—	—

Curvature  $C_{\text{star}} = 0.000$  mm.

Weighted mean

-32.9

Mean -32.2

$$T_{\text{mean}} = -38.22$$

$$T_{\text{star}} = -41.00$$

Reduction to Sun

-38.91

Radial Velocity

-24.7 km.

1922, July 20, G. M. T. 19<sup>h</sup> 50<sup>m</sup>  
Hour angle W 1° 30'

## + DELPHINI - A 309

Star fixed; comparison fixed.

Measured by A.  
Power 13

Mean of Surfaces	True Image of Primary	Comparison in Cross Lines	Comparison in Star Lines	Corrected Star Position	Displacement	Parallax	Measure
$T_1$ 25 56.0	Standard	$\pm 0.000$	—	448.084	—	—	—
$S_1$ 25 56.0	4480.100	—	$\pm 0.000$	448.084	—	—	—
$S_2$ 25 56.0	4480.000	—	$\pm 0.000$	448.080	$-0.006$	$-39.1$	2
$T_2$ 25 57.0	4480.200	$-0.008$	—	448.080	$-0.008$	$-39.1$	2
$T_3$ 25 57.0	Standard	$\pm 0.000$	—	448.080	—	—	—
$T_4$ 34 21.0	4481.070	$\pm 0.020$	—	448.080	—	—	—
$T_5$ 34 21.0	4480.000	$-0.004$	—	448.080	—	—	—
$S_3$ 34 24.0	4477.000	—	$\pm 0.000$	447.075	$-0.004$	$-38.8$	1
$S_4$ 34 24.0	4480.000	—	$\pm 0.000$	448.080	$-0.002$	$-38.1$	2
$T_6$ 35 11.0	4480.000	$\pm 0.000$	—	448.080	—	—	—
$T_7$ 35 00.0	Standard	$\pm 0.000$	—	448.080	—	—	—

Curvature  $C_{\text{star}} = 0.000$  mm.

Weighted mean

-31.4

Mean -31.8

$$T_{\text{mean}} = -35.28$$

$$T_{\text{star}} = -40.14$$

Reduction to Sun

-35.14

Radial Velocity

-26.4 km.

1902, July 31, G. M. T. 16<sup>h</sup> 45<sup>m</sup>

Hour angle E 1° 5'

Star slightly weak; comparison good.

Measured by A.  
Power 13

Mean of Settings	Wave-length in Foghorn	Correction to Comp. Lines	Correction to Star Lines	Normal Wave- Length	Displacement	Velocity	Weight
	t. m.	t. m.	t. m.	t. m.	t. m.	km.	
Ti 22.5790	4386.956	+0.051	...	4387.007	...	...	...
S 22.6225	4387.574	...	+0.049	4388.100	-0.477	-32.6	1
Ti 23.6921	Standard	±0.000	...	4389.935	...	...	...
S 25.1003	4416.725	...	-0.018	4417.121	-0.414	28.1	1
Ti 25.1978	4417.903	-0.019	...	4417.884	...	...	...
Ti 25.9676	4427.277	-0.011	...	4427.266	...	...	...
S 26.7834	4437.355	...	-0.027	4437.718	-0.390	26.4	1
Ti 27.7398	4449.360	-0.047	...	4449.313	...	...	...
Ti 29.2448	4468.683	-0.020	...	4468.663	...	...	...
S 29.4421	4471.257	...	-0.016	4471.676	-0.435	29.2	2
S 30.1842	4481.020	...	±0.000	4481.400	-0.380	25.4	2
Ti 30.2157	Standard	±0.000	...	4481.438	...	...	...
Ti 37.8308	Standard	±0.000	...	4590.126	...	...	...

Curvature Cor. +0.0005 mm.

Weighted mean -2.80

Mean -28.3

$$\begin{aligned} V_a &+1.91 \\ V_d &+0.09 \end{aligned}$$

Reduction to Sun +2.00

Radial Velocity -26.0 km.

SUMMARY OF MEASURES OF  $\epsilon$  DELPHINI

Plate	Date	Adams	No. of Lines
A 349	1902, July 11	-27.8	4
A 353	July 16	-24.7	3
A 359	July 23	-26.4	4
A 363	July 31	-26.0	5
Mean		-26.2 km.	
Mean of all measures		-26.2 km.	

## SUMMARY OF RADIAL VELOCITIES

The table which follows gives a summary of the results for the stars which we have considered in this paper. As the final velocity of each star the mean of all the measures has been adopted, so that a plate measured by both observers will have twice as much weight as a plate measured by only one. This procedure has seemed preferable to that of assigning unit weight to each plate without regard to the number of measures made of it, but the difference between the values found in the two ways is in general very slight, as a brief inspection of the summaries given at the end of the detailed measurements of each star at once shows. Column six of the table below accordingly gives the total number of measures for the individual stars, while the following column indicates the epoch to which the final velocity belongs. For comparison a list of the proper motions of the stars is appended, the values of which have been very kindly communicated to us by Professor Lewis Boss, in advance of their publication in his "Catalogue of 627 Principal Standard Stars" in the *Astronomical Journal* (Nos. 531, 532, February, 1903). For the three stars not included in his "Catalogue" (67 *Ophiuchi*, 102 *Herculis*, and  $\eta$  *Lyrae*) Professor Boss was good enough to furnish us with values in systematic conformity therewith. The proper motions correspond to Professor Newcomb's value of the precession.

## SUMMARY

Mag.	Star	R. A.	Dec.	RADIAL VELOCITY	No. of Meas- ures	Epoch	PROPER MOTION		
							R. A.	Dec.	Great Circle
3.0	$\gamma$ Pegasi	0 <sup>h</sup> 08 <sup>m</sup>	+14° 38'	+ 5.4	12	1902.06	0.0000	-0.013	0.013
3.7	$\zeta$ Cassiopeiae	0 31	+53 21	+ 2.9	6	1902.10	+0.0024	-0.007	0.023
3.6	$\epsilon$ Cassiopeiae	1 47	+63 11	- 5.9	8	1902.08	+0.0058	-0.017	0.043
3.1	$\xi$ Persei	3 48	+31 35	+22.1	7	1901.95	+0.0009	-0.017	0.020
0.3	$\beta$ Orionis	5 10	- 8 19	+20.7	24	1901.95	+0.0001	-0.001	0.002
1.9	$\gamma$ Orionis	5 20	+ 6 15	+18.0	10	1901.98	-0.0004	-0.019	0.020
1.8	$\epsilon$ Orionis	5 31	- 1 16	+26.7	7	1902.05	0.0000	-0.002	0.002
1.9	$\zeta$ Orionis	5 36	- 2 00	+18.3	7	1902.52	+0.0005	-0.007	0.010
2.2	$\kappa$ Orionis	5 43	- 9 42	+17.1	10	1901.88	+0.0001	-0.005	0.005
2.0	$\beta$ Canis Majoris	6 18	-17 54	+32.6	5	1901.84	-0.0004	0.000	0.006
1.5	$\epsilon$ Canis Majoris	6 55	-28 50	+27.2	4	1902.61	+0.0004	-0.001	0.005
3.6	$\eta$ Leonis	10 02	+17 15	+ 3.5	5	1902.31	-0.0001	-0.012	0.012
2.8	$\gamma$ Corvi	12 11	-16 59	- 7.0	6	1902.27	-0.0113	+0.011	0.162
3.9	$\tau$ Herculis	16 17	+46 33	-12.7	6	1902.21	-0.0012	+0.031	0.033
3.3	$\zeta$ Draconis	17 08	+65 50	-14.4	8	1902.19	-0.0021	+0.020	0.024
3.9	$\iota$ Herculis	17 37	+46 04	-16.4	6	1901.92	-0.0010	-0.006	0.012
4.0	67 Ophiuchi	17 56	+ 2 56	- 3.1	4	1902.47	+0.0003	-0.016	0.017
4.5	102 Herculis	18 04	+20 48	-10.8	5	1902.62	+0.0003	-0.011	0.012
4.5	$\eta$ Lyrae	19 10	+38 58	- 9.1	6	1902.74	-0.0002	-0.004	0.005
4.1	$\epsilon$ Delphini	20 28	+10 58	-26.2	4	1902.55	+0.0006	-0.026	0.027

The distribution of positive and negative velocities in the table shows clearly the direction of the motion of the Sun in space, although the number of stars is, of course, much too small to warrant the determination of the apex or velocity. Conversely, the position of the apex is not accurately enough known to make it seem desirable to tabulate the radial velocities corrected for the solar motion. It is evident on inspection, however, that the absolute velocities of these stars are very small, and a computation, based upon Newcomb's adopted apex (R. A. 277.5; Dec. — +35°) and Campbell's solar velocity (19.9 km.), gives 7.0 km. as the mean of the twenty radial velocities after correction for the solar motion; if the sign be regarded, the mean becomes +4.6 km. The exceedingly small proper motions, for stars as bright as these, are striking (in the mean 0.023; or, omitting  $\gamma$  Corvi, which is exceptional, 0.015), being much smaller than for solar stars of corresponding brightness, and indicate that the stars of the *Orion* type are as a class very remote. The bright stars of the constellation *Orion* evidently group themselves both as to the direction and magnitude of their motions.

The radial velocities of but four of the stars in the list have been previously published, by Vogel and Scheiner in Vol. VII of the Potsdam Publications. They are as follows:

$\beta$ Orionis	-	-	-	+16.3 km.	$\epsilon$ Orionis	-	-	-	+26.7
$\gamma$ Orionis	-	-	-	+ 8.9	$\zeta$ Orionis	-	-	-	+14.8

Except in the case of  $\gamma$  Orionis the agreement with the values which we have found above is quite satisfactory in view of the character of the spectra, which are most difficult of measurement.

In the course of our observations the following seven stars with spectra of the *Orion* type have been found to have variable radial velocities, and are reserved for discussion elsewhere:<sup>15</sup>

$\delta$  Ceti;  $\nu$  Eridani;  $\eta$  Orionis;  $\beta$  Cephei;  $\circ$  Persei;  $\pi^2$  Orionis;  $\zeta$  Tauri.

<sup>15</sup> See *Astrophysical Journal*, Vol. XV (1902), pp. 214, 340; *ibid.*, Vol. XVII (1903), pp. 150-52.

## REMARKS ON THE CLASSIFICATION OF THE SPECTRA

Although all of the stars which we have investigated in this paper belong to type *Ib* of Vogel's classification, their spectra vary greatly both as regards the number and the character of the lines present, and a few subdivisions are certainly desirable. Miss Maury's classification is excellent in this respect, and has the great advantage of being based upon photographs which show a very wide range of spectrum, including the valuable H and K region. From this point of view any attempt at classification based upon the limited range of spectrum given by a high-dispersion spectrograph must be distinctly inferior. A further disadvantage in discussing the characteristics of the spectra which we have obtained lies in the fact that the quality of plates best adapted to determinations of radial velocity is generally quite different from that which would be most suitable for qualitative examination; and the greater density demanded may effectually conceal some of the fainter lines present in the spectra. On the other hand, the higher dispersion and consequent broadening of the spectral lines undoubtedly enable one to judge much better of the behavior and character of the individual lines than would be possible with low dispersion and a small scale. At most, however, the classification of such a limited number of stars as we deal with here must of necessity be mainly empirical, and any order of arrangement will represent rather the succession of the various spectra as regards complexity and character of the lines than the sequence of development of the stars themselves.

The lines which occur in the spectra of the stars which we have investigated, and upon which any classification must be based, are due to the following elements: hydrogen, helium, magnesium, silicon, oxygen, and nitrogen. In some stars faint metallic lines also appear, and there are a few lines as yet unidentified. The extent of spectrum included in this examination of our plates is from  $\lambda 4300$  to  $\lambda 4720$ .

In what are probably the earliest stars of this type in order of development no lines are present with the exception of the hydrogen and stronger helium lines, and these are faint, and extremely broad and diffuse. Most of them contain the line  $H\gamma'$  at  $\lambda 4542$ , which belongs to the series of hydrogen lines first found by Pickering in the spectrum of  $\zeta$  Puppis, and some of them show the line at  $\lambda 4686$ , which Rydberg calls the first line of the hydrogen spectrum. Both of these lines are represented by bright bands in the spectra of stars of the Wolf-Rayet type. In the stars which appear most naturally to come next in order these lines disappear, and the hydrogen and helium lines increase in strength, at the same time becoming narrower and more sharply defined. The earliest of this group of stars show traces of the magnesium line at  $\lambda 4481$ , and the silicon lines at  $\lambda 4553$ ,  $\lambda 4568$  and  $\lambda 4575$ . While the magnesium line, however, rapidly increases in strength, becoming in the later stars of the group one of the most prominent lines in the spectrum, the silicon lines remain comparatively unimportant. The spectra of the furthest developed stars of this sort, such as  $\iota$  Herulis and  $\beta$  Oriouis, are characterized by strong and fairly well defined lines of hydrogen and helium, a strong and narrow line at  $\lambda 4481$ , and traces of the silicon lines. Faint metallic lines also appear at this point, the most prominent being at  $\lambda 4550$  and  $\lambda 4584$ , and indicate the connection of these stars with those distinguished by metallic lines. These last are represented among the stars investigated by  $\xi$  Tauri,  $\eta$  Corri, and  $\eta$  Leonis, and show a great decline in intensity for the helium lines accompanying the rise of the metallic lines. The magnesium line  $\lambda 4481$ , however, is very weak in the case of  $\xi$  Tauri, though strong in the other two stars; and this fact, together with the remarkable character of its hydrogen lines, which are of a sharpness and brilliancy not approached in any of the other stars, makes the spectrum of this star one of the most interesting that we have encountered.

Up to this point the order of succession of the spectra seems to be fairly clear, but those containing oxygen and nitrogen lines are much harder to classify. This difficulty arises from the fact that in other respects they seem to be almost identical with those which we have just considered. There is the same rise in intensity and increase in sharpness on the part of the hydrogen and helium lines, and the magnesium line appears and develops in almost exactly the same way, reaching nearly,

though never quite, the intensity which it has in such stars as  $\beta$  *Orionis*. On the other hand, we find in the earliest stars of this group the beginnings of a whole series of oxygen and nitrogen lines which develop simultaneously with the hydrogen, helium, and magnesium lines, and attain in the later stars of the group, such as  $\beta$  *Canis Majoris* and  $\gamma$  *Pegasi*, a high degree of prominence. The fact that the three silicon lines, which in the stars considered before never became at all marked features of the spectrum, now follow the behavior of the oxygen and nitrogen lines and gain in intensity with them, is of interest as showing that the stellar conditions seem to be favorable to the simultaneous development of the spectra of the three elements. An examination of these characteristics of the spectrum appears to make the relationship of this group of stars to that which we have considered before one of parallelism rather than succession. For while the order of succession of the individual stars within the two groups is so well defined as to preclude the insertion of either within the other, an attempt to make one follow or precede the other would be equally difficult, without the assumption of the absence of more connecting links than would be justified. Accordingly, it has seemed best to assume a point of division immediately after the earliest stars of the list, and to arrange the stars exhibiting no oxygen or nitrogen lines in their spectra along one branch, while the stars which are characterized by such lines proceed along the other.

In the following table the twenty stars discussed in this paper, together with some others of this type of which we have one or more plates, are collected and arranged. Those whose spectra are very closely allied are connected with brackets, and within the brackets the individual stars are placed in the order of increasing intensities of the lines mentioned.

$\kappa$ <i>Draconis</i> $\iota$ <i>Orionis</i> <i>S Monocerotis</i> $\lambda$ <i>Orionis</i>		Only hydrogen and stronger helium lines present with $H\gamma$ and $\lambda 486$ . All lines extremely broad and diffuse. Possibly a trace of $\lambda 4481$ in $\lambda$ <i>Orionis</i> .	
$\pi^1$ <i>Orionis</i> $\epsilon$ <i>Delphini</i> $\epsilon$ <i>Cassiopeiae</i> $\eta$ <i>Lyrae</i> $\zeta$ <i>Draconis</i> $\tau$ <i>Herculis</i> $\iota$ <i>Herculis</i> $\beta$ <i>Orionis</i>	All lines growing narrower and sharper, with $\lambda 4481$ and helium lines stronger. Traces of silicon lines. No oxygen or nitrogen lines.	$\zeta$ <i>Orionis</i> $\epsilon$ <i>Orionis</i> $\kappa$ <i>Orionis</i>	Lines stronger than above but very diffuse. Traces of $\lambda 4481$ and silicon lines. Traces of a few oxygen and nitrogen lines with strong $\lambda 4649$ .
$\zeta$ <i>Tauri</i> $\gamma$ <i>Corvi</i> $\eta$ <i>Leonis</i>	Helium lines much weaker. Metallic lines grow stronger.	67 <i>Ophiuchi</i> 102 <i>Herculis</i> $\pi^4$ <i>Orionis</i> $\chi^2$ <i>Orionis</i> $\gamma$ <i>Orionis</i> $\xi$ <i>Persei</i> $\eta$ <i>Orionis</i> $\beta$ <i>Cephei</i> $\xi$ <i>Cassiopeiae</i> $\epsilon$ <i>Canis Majoris</i> $\beta$ <i>Canis Majoris</i> $\delta$ <i>Ceti</i> $\gamma$ <i>Pegasi</i>	All lines growing narrower and sharper, with $\lambda 4481$ , helium, and silicon lines stronger. Oxygen and nitrogen lines increase in number and grow sharper and stronger.

## DESCRIPTION OF THE PLATES

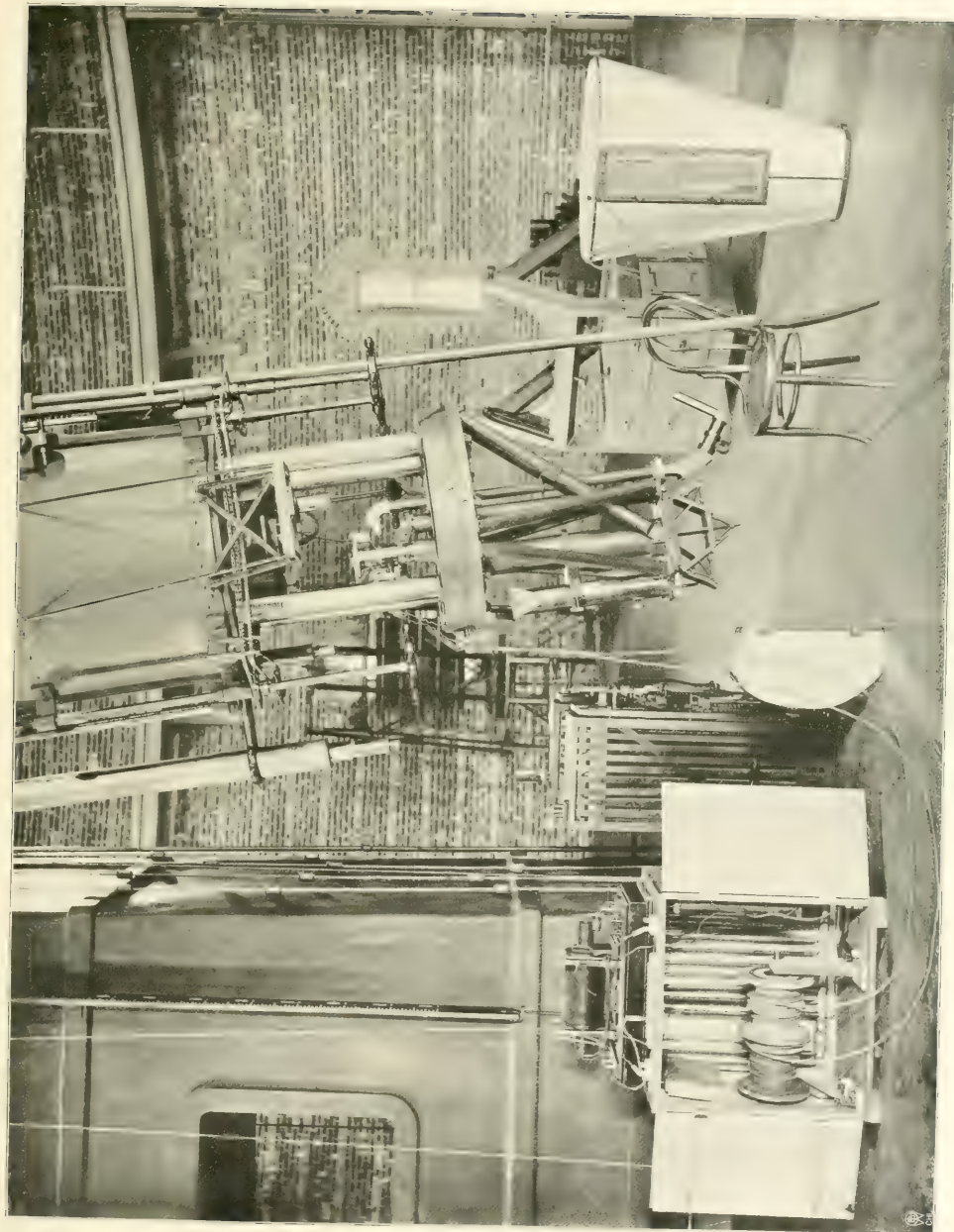
Plate I shows the spectrograph attached to the forty-inch telescope. The cells containing each of the three prisms may be readily seen, rigidly attached to the main casting, in their invariable position. The twenty-four inch camera tube for camera lens B is seen in place. The chair is set in the proper position for an observer to conveniently look down into the guiding telescope. The tube extending from the guiding telescope below to the "goose-neck" above conveys the rays which have been reflected from the polished slit jaws, and then caught and deflected downward by diagonal prisms within the "goose-neck." To the left of this may be seen the apparatus for producing the comparison spectrum, and the slit, although the scale of the illustration does not permit the details to be clearly apparent. The long rod which would be at the left hand of an observer sitting in the chair is used to assist in guiding, and the whole telescope may be slightly sprung to follow the star. The switches controlling the electric slow motions in right ascension and declination, which are always within easy reach of the observer, could not be shown when the temperature case was removed, as here. The light inner aluminium case, or prism box, is seen on the floor at the left below the prisms. The double-walled outer temperature case, which incloses the whole spectrograph, except the slit, is at the extreme right. Behind it is the carriage upon which the spectrograph rests when not attached to the telescope. The induction coil is seen at the left. The box beneath it contains the condenser (at left), the self induction coil (at right), and the drum upon which is wound the cable conveying the secondary current to the spectrograph.

Plate II shows the comparator made by Gaertner & Co., which is sufficiently described on p. 6.

Several examples of spectra described in this paper are given in Plate III. The negatives used were  $\alpha$  *Boötis*, B 500;  $\beta$  *Orionis*, B 282;  $\beta$  *Canis Majoris*, B 215;  $\epsilon$  *Canis Majoris*, B 461; and  $\eta$  *Leonis*, B 329.

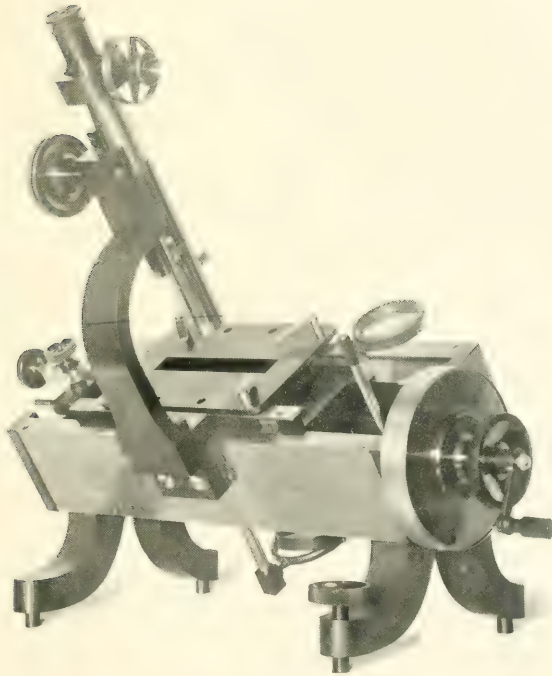
A recent important modification of the pendulum apparatus for vertical enlargement of spectra has permitted the comparison spectrum to receive the same treatment as the stellar spectrum. The positives from which the half tone blocks were made were prepared by Mr. Ellerman. As shown here the enlargement over the original negatives is vertically almost forty fold, and horizontally only four fold (3.8). Any process of vertical enlargement necessarily introduces false lines in the stellar spectra, which may be confusing in spectra having few lines, although inconspicuous in the spectra of the solar type. We have accordingly indicated the chemical origin of all of the more important lines on the three spectra having the fewest lines.

The plates have not been retouched by photographer or engraver, but the intensity of the continuous spectrum was rendered as uniform as possible by shading the brightest parts during the process of enlargement.



THE BRUCE SPECTROGRAPH WITH ITS ACCESSORIES





MEASURING MACHINE FOR STELLAR SPECTRA





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BY THE UNIVERSITY OF CHICAGO

## THE SPECTRA OF STARS OF SECCHI'S FOURTH TYPE

GEORGE E. HALE, FERDINAND ELLERMAN, AND J. A. PARKHURST

THE possibility of basing a systematic scheme of stellar evolution on spectroscopic observations is foreshadowed in the work of Fraunhofer, who in 1823 observed for the first time the spectra of a few of the brightest stars. Though wholly ignorant of the origin of the dark lines in these spectra, Fraunhofer recognized that their number, appearance, and grouping differed greatly from star to star, and that in certain cases the solar spectrum seemed to be exactly duplicated. But it required such a general survey as that of Secchi, who examined the spectra of more than four thousand stars, to afford any basis for a scheme of classification. The purely empirical classification which he adopted includes a very large percentage of the stars among its five principal types, and subsequent systems have done little more than to add subgroups to provide for the comparatively few peculiar spectra which do not fall within Secchi's divisions.

Secchi's classification, as we have said, was a purely empirical one, intended to serve only as a convenient means of grouping similar spectra. But the researches of Huggins and Vogel soon introduced the idea of development, and the changes of spectra from type to type came to be regarded as synonymous with progressive changes in the stars themselves. Spectroscopists have agreed in regarding the white stars, with spectra characterized by the predominance of the series of hydrogen lines (Secchi's first type), as representing an early stage of development, corresponding to a condition of low density. Through the continued action of gravity, accompanied by loss of heat, the absorbing metallic vapors increase in density, producing a marked increase in the number and strength of the metallic lines, while the hydrogen lines become narrower and less conspicuous (Secchi's second type). The reduction of light caused by the greater absorption is most marked at the violet end of the spectrum, causing the color of the star to change from white to yellow. After passing this, the solar, stage, further operation of the same causes results in the production of red stars, whose spectra might be expected to indicate comparatively low temperature and high density of the absorbing vapors.

It is not clear, however, why there should be two distinct classes of red stars, characterized by widely different banded spectra. One of these classes (Secchi's third type), which includes such bright stars as  *$\alpha$  Orionis*,  *$\alpha$  Scorpii*, and  *$\alpha$  Herculis*, is comparatively well known. In the pioneer days of stellar spectroscopy Huggins and Vogel measured some seventy lines in the spectrum of  *$\alpha$  Orionis*, and the more refrangible region of the spectra of some of these stars has more recently been studied photographically by these and other observers. But much remains to be done by photographic means, particularly in the less refrangible region, where Keeler was working with marked success when interrupted by his untimely death. In the present paper our photographs of the spectra of some of these stars are reproduced for comparison with the spectra of stars of Secchi's fourth type, but the measurement of these photographs has not yet been undertaken.

As the other great class of red stars (Secchi's fourth type) includes no objects brighter than magnitude 5.3, it is obvious that the detailed investigation of their spectra is beyond the reach of telescopes of small aperture. It will be seen from the references given below that the general characteristics of these spectra were clearly recognized in the visual observations of Secchi, Dunér, Vogel, and others, but it was impossible with the instruments employed by them to observe more than the carbon bands and two or three prominent lines. Even the objective prism, as applied in conjunction with photography, has failed to show the less conspicuous details, though it has been invaluable in discovering new objects and in showing the relative intensities of the various bands in different stars. As the great light-gathering power of the forty-inch Yerkes refractor seemed to render it especially suitable for an investigation of these faint stars, the work described in this paper was undertaken in

January, 1898. In conjunction with this investigation photographs have been made of the spectra of a number of stars of other types, researches on the condition of carbon in the solar chromosphere and on the widened lines in Sun-spots have been set on foot, and considerable work on the spectrum of carbon and other substances has been done in the laboratory.

#### REVIEW OF PREVIOUS OBSERVATIONS

In his first classification of stellar spectra Secchi made no distinction between the two types of red stars. Indeed, a star later recognized by him as of the fourth type (*Lalande* 12,561) was classed in the memoir *Sugli spettri prismatici delle stelle fisse* (*Memoria Prima*, 1867) with *a Herculis* in the following words (*Catalogo*, p. 14): "In conclusione è tipo di *a Ercole*, ma con zone nere mancanti, onde le sue sono large tanto, che alcune ne abbracciano due di quelle di *a Ercole*." After giving measurements to show the agreement in the position of the bands with those of *a Herculis*, Secchi adds, however: "Le zone sono notabili per avere il verso della luce in senso opposto dell' ordinario."

In the second memoir (*Memoria Seconda*, 1868) it appears that the distinctive characteristics of fourth-type spectra were recognized in the course of a survey of some twenty red stars from Schjellerup's catalogue. In describing the spectrum of 152 *Schjellerup* as characteristic of the class, Secchi remarks (p. 9):

Questo tipo è dunque composto di tre sole zone principali; una viva nel verde, una debole nel bleu e una assai viva nel rosso. Quest' ultima è spesso suddivisa in altre zone minori.

Questo tipo differisce essenzialmente dal 3° non solo per la divisione della zone, le quali hanno una larghezza doppia, ma anche perchè le zone hanno la maggiore intensità luminosa in verso opposto. Cioè esse nel 4° tipo vanno crescendo di luce dal rosso verso il violetto, mentre quelle del terzo sono disposte al contrario. Talechè rappresentando il 3° tipo come un sistema di colonne, il quarto sarebbe rappresentato da cavità, supponendo la luce illuminante diretta nello stesso verso.

Few objects having spectra of the fourth type were known to Secchi, but many were discovered in the subsequent observations of Vogel, D'Arrest, Dunér, Pickering, and Espin. Pickering's first discoveries were made visually, but a very large percentage of the fourth-type stars discovered at the Harvard Observatory have been found on photographs taken with an objective prism. Qualitative observations of various fourth-type spectra, made with a small direct-vision spectroscope, are given by Friedrich Krueger in his "Catalog der farbigen Sterne."<sup>1</sup> McClean photographed the spectrum of 152 *Schjellerup* with an objective prism in 1896. He describes his results as follows:<sup>2</sup>

Two different photographs are given of the star 152 *Schjellerup* of the 5½ magnitude. Two hours' exposure was required, which accounts for the exaggerated distortion due to the changing amount of refraction during exposure. The value of the faint details is enhanced by the correspondence of the two photographs. The presence of a line absorption spectrum is distinctly shown, and it appears to agree to a marked extent with the usual line spectrum of Types II and III. There appears to be no trace of Dunér's Band No. 5 of Type III. The inference seems to be that spectra of Type IV arise from a natural course of change in these stars, passing directly from Type II. They are stars of Type II become less luminous, but not different in kind.

McClean also reproduces objective-prism photographs of the spectra of 19 *Piscium* and 152 *Schjellerup* in an article in the *Philosophical Transactions*, Vol. CXCI, A, p. 131, Plate XIV. His photograph of 19 *Piscium* shows only the bands, but in the two spectra of 152 *Schjellerup* some of the more conspicuous dark lines are visible. These photographs were the first to show any of the lines; unfortunately they do not seem to have been measured. A large number of fourth-type spectra have been photographed with the objective prism at the Harvard Observatory, but while the bands are well shown, the lines do not appear in these photographs. A complete list of all fourth-type stars known at that time was published in 1898 by Espin,<sup>3</sup> who has himself discovered many objects of this character. The classic memoir published by Dunér in 1884, "Sur les étoiles à spectres de la troisième classe,"<sup>4</sup>

<sup>1</sup> *Spektroskopische Untersuchungen*, Kiel, Band VIII, Kiel, 1893.

<sup>2</sup> *Monthly Notices*, Vol. LXII, p. 8.

<sup>3</sup> *Ibid.*, Vol. LVIII, p. 443.

<sup>4</sup> *Svenska Vetenskaps-Akademiens Handlingar*, Vol. XXI, No. 2.

Vogel's observations with the twenty-seven-inch refractor of the Vienna Observatory,<sup>5</sup> and McClean's photographs of 152 *Schjellerup* have afforded the best available data for the study of the spectra.

Dunér's important observations, which are frequently to be referred to in this paper, were made with several direct-vision spectroscopes of different dispersive powers attached to the ten-inch refractor of the Lund Observatory. In spite of the insufficiency of his instrumental equipment, which prevented him from seeing the dark and bright lines in the spectra of fourth-type stars, Dunér's results are of the highest value, and his conclusions are confirmed in almost every particular by our photographs. In a recent paper<sup>6</sup> Dunér has described his observations of bright lines in fourth-type spectra, made at the Upsala Observatory with a telescope of 36 cm. aperture. Further reference to these observations will be made below. Dunér's drawings of fourth-type spectra are reproduced from his first memoir in Plate V. His general description of fourth-type (*IIIb*) spectra is as follows:

Les spectres des étoiles de la classe *IIIb* consistent, s'ils sont parfaitement développés, en quatre zones brillantes, séparées par des bandes obscures, dégradées vers le violet, et d'une largeur extraordinaire, au moins le double de celles de la classe *IIIa*. La zone rouge-jaune est subdivisée par des bandes plus faibles et moins larges, dégradées soit vers le rouge, soit vers les deux côtés. La sous-zone jaune (longueur d'onde 563-589) est ordinairement la partie la plus brillante du spectre entier, et elle, ainsi que la sous-zone rouge voisine (longueur d'onde 589-621), est divisée en deux par une bande bien marquée, mais si étroite qu'elle ressemble, dans des spectroscopes d'une faible dispersion, à une raie ordinaire. En outre il y a, dans la zone verte, deux raies, ou peut-être deux bandes très étroites.

Ces caractères sont, j'en suis sûr, non moins constants, dans les spectres de cette classe, que le sont pour la classe *IIIa* ceux donnés ci dessus, et on les reconnaîtra indubitablement chez toutes les étoiles qui y appartiennent, à mesure qu'on pourra les examiner avec des lunettes suffisamment fortes, et à mesure que les étoiles se trouveront dans une phase de développement suffisamment avancée. Dans une lunette de 245 millimètres d'objectif comme la nôtre, il y a cependant des détails dans les spectres de la plupart de ces étoiles, qu'on ne peut apercevoir. D'abord les bandes secondaires, et les raies dans la zone verte sont plus ou moins invisibles dans les spectres des étoiles faibles, et même dans les étoiles les plus brillantes (5<sup>m</sup>. 5 seulement!) leur intensité peut être très différente. Puis l'intensité de la lumière des zones brillantes peut varier considérablement chez des étoiles de la même grandeur. Dans les étoiles d'un rouge foncé, la zone ultra-bleue est extrêmement faible en comparaison avec la même zone dans les étoiles rouge-jaune; et chez les étoiles faibles, cette zone est tout-à-fait invisible, et même la zone bleue est très difficile à voir si elles sont très rouges.

Mais aussi la bande principale à la longueur d'onde 563 est d'une opacité très variée. Chez certaines étoiles, elle est presque aussi foncée que les deux autres bandes principales; mais dans certains spectres elle est assez faible, et semble, probablement à cause de cela, être beaucoup moins large que les bandes aux longueurs d'onde 516 et 473. Celles-ci, et surtout la première d'entre elles, sont toujours très fortes et très larges, et forment le caractère le plus prononcé de ces spectres. Toutes les étoiles de cette classe sont très fortement colorées, au moins d'un rouge-jaune fort mais quelques-unes d'entre elles sont presque rouges.<sup>7</sup>

Dunér's measures of fourth-type (*IIIb*) spectra, as tabulated on p. 122 of his memoir, are given below, reduced to Rowland's scale:

WAVE-LENGTHS DETERMINED BY DUNÉR

OBJECT	19 <i>Piscum</i>	132 <i>Schj.</i>	132 <i>Schj.</i>	132 <i>Schj.</i>	132 <i>Schj.</i>	WAVE-LENGTH
Band 2.....	621	.....	.....	.....	.....	621
Band 3.....	6049	.....	.....	.....	.....	6049
Band 4 (maximum).....	5896	5885	.....	5896	5911	5899
Band 5.....	5761	5758	5748	5763	5762	5761
Band 6 (beginning).....	.....	5641	5625	5634	5635	5634
Band 7.....	551	.....	.....	.....	.....	551
Band 6 (end).....	.....	.....	.....	.....	545	545
Band 8.....	5286	.....	.....	.....	5281	5284
Band 9 (beginning).....	.....	5168	5160	5161	5165	5164
Band 9 (end).....	.....	.....	.....	.....	496	496
Band 10 (beginning).....	.....	4715	4721	4730	4740	4728
Band 10 (end).....	463	.....	.....	.....	.....	463
End of spectrum.....	.....	.....	437	.....	.....	437

<sup>5</sup>Publicationen der Astrophysikalisches Observatorium zu Potsdam, Vol. IV, Part I.

<sup>6</sup>"On the Spectra of Stars of Class *IIIb*," *Astrophysical Journal*, Vol. IX (1899), p. 119.

<sup>7</sup>*Loc. cit.*, pp. 9, 10.

In his observations at Bothkamp, and in his later work with the twenty-seven-inch Vienna refractor, Vogel measured the spectra of the stars Nos. 51, 78, 152, and 273 of Schjellerup's catalogue, and also that of *DM. + 34 4500*. Vogel's drawings of the spectra of 152 *Schjellerup* and *DM. + 34 4500* are reproduced in Plate V. His measures (reduced to Rowland's scale) are given in the following table, which is taken from Vol. IV of the *Potsdam Publications*:

WAVE-LENGTHS DETERMINED BY VOGEL

OBJECT	152 <i>Scf.</i> (Vienna)	152 <i>Scf.</i> Vienna	152 <i>Scf.</i> (Bothkamp)	<i>DM. + 34 4500</i> (Vienna)	273 <i>Scf.</i> (Bothkamp)	78 <i>Scf.</i> Bothkamp	51 <i>Scf.</i> Bothkamp	MEAN
Beginning of spectrum.....			660	.....	.....	.....	.....	660
Dark band.....		.....	.....	.....	656	.....	.....	656
Dark band.....		.....	622	.....	622	623	.....	622
Dark band.....		.....	.....	.....	6066	.....	.....	6066
Line in a band.....	5892	.....	5893	5890	589	590	.....	5894
End of band.....	5849	.....	.....	.....	.....	.....	.....	5849
Line.....	5742	.....	5759	5751	578	5756	.....	5758
Line beginning a band.....	5622	5626	5629	5621	564	564	5641	5632
Line.....	.....	.....	552	.....	552	.....	.....	552
Line.....	.....	.....	544	.....	.....	.....	.....	544
Group of lines.....	.....	.....	528	527	529	.....	.....	528
Line beginning a band.....	5160	5164	5157	5162	516	515	5166	5160
Line.....	5133	.....	.....	.....	.....	.....	.....	5133
Beginning of band.....	4717	.....	4736	4745	472	473	.....	4730
Band.....	.....	.....	437	.....	.....	.....	.....	437
End of spectrum.....	.....	.....	430	.....	.....	.....	.....	430

The combined results of the two observers, compared with Kayser and Runge's wave-lengths of the "hydrocarbon" bands, are contained in the following table:<sup>8</sup>

COMPARISON OF WAVE-LENGTHS

OBJECT	VOGEL	DUNER	MEAN	SWAN SPECTRUM
Spectrum begins.....	660	.....	660	
Dark band.....	656	.....	656	
Dark band.....	622	621	6215	
Dark band.....	6066	6049	6058	6060 Middle of red band
Line in a band.....	5894	5899	5897	
End of a band.....	5849	.....	5849	
Line.....	5758	5761	5760	
Line beginning a band.....	5632	5634	5633	5635.43 Beginning of yellow band
Line.....	552	551	5515	
Line.....	544	545	5445	
System of lines.....	528	5284	5282	
Line beginning a band.....	5160	5164	5162	5165.30 Beginning of green band
Line.....	.....	496	496	
Line.....	5133	.....	5133	
Beginning of a band.....	4730	4728	4729	4737.18 Beginning of blue band
Line.....	.....	463	463	
Band.....	437	437	437	4381.93 Beginning of fifth band
End of spectrum.....	430	.....	430	

In discussing these results Scheiner, basing his conclusion on the supposition that the hydrocarbons are all reduced to acetylene ( $C_2H_2$ ) at high temperatures and are characterized by a common spectrum which perhaps belongs to this substance, remarks: "We may, therefore, go a step farther and consider that in the stars of Class IIIb carbon and hydrogen are united in the form of acetylene, which is the first combination of these two elements which would ensue as the temperature fell." It will be shown later in this paper that this conclusion must in all probability be modified on account of recent advances in our knowledge of the spectra of carbon compounds.

Of the 242 stars of the fourth type catalogued by Espin there are but three in the northern hemisphere and four in the southern that are brighter than the sixth magnitude. Of the stars which

<sup>8</sup> *Stellar Spectra and Astronomical Spectroscopy*, p. 314

have been observed photometrically Espin finds twenty-three between magnitude 6.1 and 7; thirty-nine between 7.1 and 8; seventy-six between 8.1 and 9; and eighty below 9. The red color of the stars is largely due to the extreme faintness of the blue and violet rays, and this fact greatly increases the difficulty of photographing the more refrangible region of their spectra.

#### INSTRUMENTS USED IN THIS RESEARCH

Most of the photographs used in the present investigation were taken with a three-prism spectrograph attached to the forty-inch refractor of the Yerkes Observatory. The form of the color-curve of the forty-inch objective has an important bearing on the relative brightness of different regions of the photographed spectra. In work on the yellow and green regions of the spectrum the slit of the spectrograph has ordinarily been set at the focus corresponding to  $\lambda$  5000. The spectra of fourth-type stars generally increase in brightness from the head of the yellow carbon band toward a maximum in the green. On account of the loss of light due to the rise in the color curve and the fall in the curve of sensitiveness of ordinary isochromatic plates in the neighborhood of the *b* group, the intensity of the photographs of spectra is more nearly uniform in the green than it should be. For a similar reason the less refrangible half of the bright zone in the yellow is too faint on our photographs. These facts should be borne in mind when examining the plates which accompany this paper; it must also be remembered that the relative intensities of different regions are affected by the shading of the photographs during enlargement, which is necessary in order to bring out the lines properly. In the blue part of the spectrum, on account of the steepness of the color curve, a correcting lens near the focal plane is required. The lens not only increases the extent of spectrum photographed on a single plate, but also facilitates guiding, and thus materially reduces the exposure time.

As the spectrograph has been fully described elsewhere,<sup>9</sup> a very few details will suffice here. It consists essentially of a Huggins reflecting slit, with guiding eyepiece, a collimator of 31 mm. aperture and focal length of 507 mm., three 60° prisms of heavy flint glass ( $n = 1.6960$ ), and several cameras of different focal lengths. The camera objective ordinarily employed is a photographic doublet of 37 mm. aperture and 271 mm. focal length. This gives the best results when used with a collimator objective corrected for the visual rays. For the faintest stars a camera with photographic doublet of 40 mm. aperture and about 150 mm. focal length was employed. In the earlier work one prism was frequently used with a camera of 508 mm. focal length, but it was soon found that much more satisfactory results could be obtained with three prisms and a short camera. The prisms are of a distinctly yellowish color, and undoubtedly exercise considerable absorption in the blue and violet. A spark between iron or titanium poles was used for the comparison spectrum. Unfortunately the spectrograph was not provided with a constant-temperature case (Plate IV).

For the brighter stars, when it is not desired to photograph a considerable range of spectrum, slit-widths ranging from 0.01 mm. to 0.04 mm. may be used to advantage, even with an instrument having the great focal length of the forty-inch telescope. In the investigations of Messrs. Frost and Adams on stellar motions in the line of sight such widths are actually employed. But in our work on the faint red stars it was found necessary to use slit-widths as great as 0.1 mm. As the camera lens commonly preferred has a focal length whose ratio to the focal length of the collimator objective is 1:1.9, it is evident that the breadth of the spectrum and also the width of the lines are reduced in this ratio. With a slit-width of 0.15 mm. and a dispersion of three 60° prisms, the yellow and green regions of the spectrum of 280 *Schjellerup* (mag. 7.8) required an exposure of nine hours.<sup>10</sup>

As recent work with the forty-inch telescope has shown that the original spectrograph is inferior in many respects to the new Bruce spectrograph, it is important that the weak points of the older

<sup>9</sup> GEORGE E. HALE AND FERDINAND ELLERMAN, "On the Spectra of Stars of Secchi's Fourth Type," *Astrophysical Journal*, Vol. X (1899), p. 93.

*Bulletin* No. 7. With the same optical combination, and with a slit-width of 0.055 mm., the green bands in the spectrum of a *Orionis* were photographed in twenty seconds.

<sup>10</sup> This photograph has been reproduced in *Yerkes Observatory*

instrument should be pointed out, on account of their bearing on the results obtained in the present investigation. The old spectrograph was constructed by Brashear in 1893. In all respects it was almost an exact duplicate of the spectrograph designed two years previously by Keeler for the Allegheny Observatory. In most particulars it was a distinct advance upon previous instruments, especially in its embodiment of Keeler's train of three prisms, giving a deviation of about  $180^\circ$ , which has been adopted in almost every spectrograph constructed since that time for the determination of stellar velocities in the line of sight. It inherited from earlier instruments, however, certain defects of construction which might give no trouble in visual observations, but have made themselves felt in the long exposures required in the present investigation. The three prisms of the train, instead of being firmly clamped in a fixed position, in accordance with the practice familiar in recent instruments, were mounted on an automatic minimum deviation device. When set for any particular part of the spectrum the prisms and camera were clamped in place. It might be supposed that such clamping would eliminate all difficulties arising from the instability of the prism supports, but experience has not shown this to be the case. As at first constructed the brass plate upon which the prisms rested was very light. This was replaced by a strong ribbed plate of much heavier brass, made after Professor Wadsworth's design in our instrument shop, which undoubtedly improved the spectrograph. The prism supports were also changed for the better, and various other modifications effected in the spectrograph at this time certainly tended to increase its efficiency. It was subsequently found, however, as has been fully explained elsewhere by Professor Frost,<sup>11</sup> that, even when all customary precautions had been taken in his use of the instrument, the velocities of stars in the line of sight determined with its aid were sometimes subject to marked uncertainty, though some of the results were excellent. There can be no doubt, therefore, that results much more satisfactory than those here presented could have been obtained if an instrument as stable as the Bruce spectrograph had been available for the present work.

It will be seen that the circumstances were not at all favorable for the accurate measurement of radial velocities, and when the work was undertaken it was not proposed to attempt such determinations. Nevertheless, precautions were taken to avoid systematic errors, and the approximate velocities of a few of the fourth-type stars have been measured. The measurement of the plates made with the old instrument has been greatly facilitated by the use of three excellent negatives obtained with the Bruce spectrograph. Had the old spectrograph been built in such a way as to eliminate all possible effects of flexure, and provided with a constant-temperature case, good determinations of velocity could undoubtedly have been obtained for stars as faint as the eighth magnitude. The experience gained in the use of this instrument has been embodied in the Bruce spectrograph, which seems to possess none of the faults of its predecessor. At present the old spectrograph is employed with the two-foot reflector.<sup>12</sup> On account of the absence of chromatic aberration in the reflector, it was found possible to obtain a photograph of the spectrum of 19 *Piscium*, extending beyond the H and K lines, with an exposure (on three nights) of twenty-four and one-half hours (Plate X).

While the precision attained in the present research is greatly inferior to that of recent investigations of stellar motions in the line of sight, it is nevertheless sufficient for many purposes. As will be shown below, photographs of the spectra of a large number of fourth-type stars with moderate dispersion, and of a few selected stars with the highest feasible dispersion, are still greatly to be desired.

#### JOURNAL OF OBSERVATIONS

Most of the photographs were taken in the yellow-green (Y. G.) or in the blue region of the spectrum, but a few in the yellow-red (Y. R.) were secured with the aid of Erythro plates. In the earlier work, and for special purposes later, a single dense flint (D. F.) prism was employed, but the train of three dense flint prisms was generally preferred. A few photographs—including those made

<sup>11</sup> "The Bruce Spectrograph of the Yerkes Observatory," *Astronomical Journal*, Vol. LV (1905), p. 12.

<sup>12</sup> G. W. RITCHIE, "The Two-Foot Reflecting Telescope of the Yerkes Observatory," *Astronomical Journal*, Vol. XLV (1901), p. 217.

with the two-foot reflector — were taken with a single light flint (L. F.) prism, and in one case a 30° prism, silvered on the back surface, was used with the solar spectrograph. The focal lengths of the various cameras are as follows: No. 0 = 151 mm., No. 1 = 271 mm., No. 2 = 508 mm., A (Bruce spectrograph) = 449 mm.

The photographic plates which proved most satisfactory were Erythro for the yellow-red, Cramer Instantaneous Isochromatic (C. I. I.) for the yellow-green, and Cramer Crown for the blue.

Star	No.	Date	Disp.	Camera	Plate	Region	H. A. Mul.	Slit	Hour	Exp.	Comp. Spectrum		Temp.		Remarks
											Exp.	End	Exp.	End	
132 Schj.	147	1898													
132 "	148	Jan. 28	1 D. F.	1	C. I. I.	Y. G.		4.0	14 15	120	3	3	Fe Spark	F.	F.
132 "	149	" 31	"	"	"	"		4.0	14 15	120	3	3	"	18.0	12.5
74 "	151	" 31	"	"	"	"		4.0	10 05	120	3	3	"	12.0	11.5
74 "	155	Feb. 2	"	"	"	"		3.0	10 58	114	30	30	"	8.5	3.0
51 "	156	" 3	"	"	"	"		3.0	6 46	165	15	15	Fe Spark	-4.0	-7.5
78 "	160	" 3	"	"	"	"		3.0	6 43	280	8	8	"	13.5	13.8
318 Birm.	160	" 6	"	"	"	"		3.0	9 42	233	4	4	"	18.7	20.5
229 Schj.	161	" 6	"	"	"	"		4.0	15 33	175	15	15	"	27.5	28.0
153 b	164	" 13	"	"	"	"		4.0	15 32	85	1	1	"	25.0	25.0
153 "	165	" 15	"	"	"	"		4.0	15 20	1	1	1	"	19.7	19.7
153 b	167	" 15	"	"	"	"		3.0	14 43	188	12	12	"	17.5	15.0
27 a	169	" 24	"	"	"	"		4.0	7 00	300	33	33	"	14.8	7.0
229 "	170	" 24	"	"	"	"		3.0	14 25	210	10	10	"	6.5	5.0
171 "	171	" 25	"	"	"	"		4.0	7 00	320	10	10	"	14.2	12.6
41 "	175	March 3	"	"	"	"		3.0	7 05	420	10	10	"	28.0	18.0
132 "	177	" 16	3 D. F.	1	"	"		3.0	7 25	190	10	10	"	47.8	42.4
132 "	178	" 16	"	"	"	"		3.0	13 22	148	10	10	"	38.8	33.3
132 "	179	" 17	"	"	"	"		3.0	7 36	244	10	10	"	40.0	33.5
132 "	181	" 24	"	"	"	"		3.0	7 28	395	13	13	"	39.0	33.5
229 "	182	" 30	1 D. F.	1	"	"		3.0	13 15	115	15	15	"	29.3	25.0
132 "	184	April 7	"	"	Crown	Blue		4.0	7 00	325	15	15	"	41.5	35.5
132 "	185	" 13	"	"	"	"		4.0	10 20	175	15	15	"	44.2	42.8
132 "	186	" 14	3 D. F.	1	"	"		4.0	7 15	346	15	15	"	52.0	44.0
246 a	187	" 15	"	"	"	"		7.0	7 22	300	15	15	"	54.0	52.0
246 a	188	May 13	1 D. F.	1	C. I. I.	Y. G.		4.0	13 35	140	15	15	Fe Spark	49.0	46.7
246 Birm.	191	" 25	"	"	"	"		6.0	11 29	245	15	15	"	56.5	52.6
246 Birm.	195	" 26	"	"	"	"		7.0	11 48	115	15	15	"	60.0	52.6
509 Birm.	196	" 29	"	"	"	"		7.0	10 25	95	4	4	"	56.0	49.0
238 Schj.	197	" 29	"	"	"	"		6.0	10 00	110	15	15	"	56.0	50.0
132 "	198	" 29	"	"	"	"		6.0	13 00	153	15	15	"	58.6	58.0
132 "	199	June 1	3 D. F.	1	"	"		3.0	8 52	322	20	20	Fe Spark	66.0	57.5
132 "	200	" 2	"	"	"	"		3.0	8 15	325	20	20	"	66.0	57.5
521 Birm.	201	" 3	1 D. F.	1	"	"		8.0	8 55	295	4	4	"	68.0	60.0
280 Schj.	202	" 3	"	"	"	"		8.0	12 44	250	10	10	"	68.0	60.0
132 "	203	" 4	"	"	"	"		7.0	10 55	135	4	4	"	72.0	60.0
132 "	209	" 17	"	"	Erythro	Y. R.		7.0	8 47	180	95	90	"	70.0	67.0
132 "	210	" 22	"	"	"	"		7.0	11 20	200	120	90	"	70.0	67.0
132 "	211	July 1	"	"	"	"		6.0	8 30	350	50	50	"	70.0	67.0
132 "	212	" 6	"	"	"	"		6.0	8 49	300	50	50	"	74.0	60.0
132 "	214	" 8	"	"	Crown	Blue		4.0	8 55	280	4	4	"	71.0	68.0
248 a	215	" 13	"	"	C. I. I.	Y. G.		5.0	11 10	195	5	5	"	69.0	67.0
19 Pisc.	216	Aug. 3	"	"	"	"		4.0	11 32	240	10	10	"	75.0	61.0
7 Schj.	217	" 18	"	"	"	"		5.0	10 55	320	10	10	"	75.0	61.0
19 Pisc.	220	" 24.25	"	"	Erythro	Y. R.		6.0	10 35	340	120	150	Fe Spark	71.0	67.0
D. M. 55	222	" 27	"	"	"	"		6.0	12 45	185	5	5	"	70.0	67.0
280 Schj.	234	Sept. 7	"	"	C. I. I.	Y. G.		3.0	7 52	365	5	5	"	57.0	55.0
19 Pisc.	242	" 27	Ref. P.	13	"	"		8.0	10 35	60	5	5	Moon	55.0	55.0
19 Pisc.	244	Oct. 26	"	"	"	"		8.0	7 44	60	3	3	"	55.0	55.0
280 Schj.	245	" 26	"	"	"	"		8.0	10 50	300	5	5	"	55.0	55.0
280 "	246	Oct. 31 and Nov. 1	1 D. F.	1	"	"		7.0	5 56	300	180	180	"	55.0	55.0
132 "	250	Dec. 22	3 D. F.	1	"	"		3.0	14 47	190	14	15	Fe Spark	47.0	42.6
318 Birm.	253	" 26	"	"	"	"		4.0	13 44	240	10	10	"	-1.1*	-3.0*
19 Pisc.	257	" 28	"	"	"	"		4.0	5 17	266	7	7	"	-2.5	-2.6
19 Pisc.	259	" 29	"	"	"	"		3.0	5 17	266	7	7	"	-4.3	-1.2
19 "	262	" 30	"	"	S. G. E.	Blue		7.0	5 12	232	3	4	"	-11.2	-16.0
132 Schj.	263	" 30	"	"	"	"		5.0	13 35	240	3	3	"	-18.0	-20.6
19 Pisc.	264	" 31	"	"	"	"		5.0	5 00	180	3	3	"	-16.0	-17.0
78 Schj.	267	1899													
132 "	268	Jan. 4	"	"	"	"		5.0	7 42	245	3	4	"	-7.0	-11.4
132 "	268	" 4	"	"	"	"		5.0	12 45	245	4	4	"	-11.5	-12.7
19 Pisc.	269	" 6	"	"	C. I. I.	Y. G.		2.0	5 20	115	4	8	"	-10.4	-13.0
74 Schj.	270	" 6	"	"	"	"		4.0	5 40	165	6	6	"	-15.0	-13.0
51 "	272	" 10.11	"	"	"	"		4.0	8 10	185	4	6	"	-5.6	-4.0
132 "	274	" 14	"	"	"	"		6.0	5 26	740	2	8	"	-1.0	-0.6
132 "	275	" 14	"	"	"	"		4.0	13 15	119	10	13	"	-0.4	-0.3
318 Birm.	276	" 15	"	"	S. G. E.	Blue		5.0	7 30	360	10	8	"	-1.0	-0.7
153 Schj.	277	" 15	"	"	"	Y. G.		4.0	14 30	160	10	7	"	+0.6	0.0
115 "	278	" 18	"	"	"	"		4.0	12 40	190	12	10	"	+2.8	9.0
19 Pisc.	283	" 20	"	"	"	"		5.0	5 17	30	10	10	"	+2.0	2.0
318 Birm.	284	" 30	"	"	"	"		4.0	9 48	235	8	10	"	-1.0	0.0
132 Schj.	285	" 30	"	"	"	"		4.0	14 12	45	8	8	"	+3.0	0.0
280 "	286	" 23	"	"	"	"		5.0	11 40	290	4	4	"	-1.0	0.0
132 "	290	" 26	"	"	"	"		4.0	11 30	118	4	11	"	-14.0	-15.5
132 "	291	" 26	"	"	"	"		4.0	13 50	135	7	11	"	-15.5	-16.5
19 Pisc.	293	" 27	"	"	"	"		4.0	5 55	125	8	6	"	-11.2	-11.5
78 Schj.	294	Feb. 10	"	"	"	"		4.0	9 30	230	17	8	"	-21.0	-22.0
229 "	296	" 10	"	"	"	"		3.0	14 35	225	12	12	"	-23.0	-23.3

Star	No.	Date	Disp.	Camera	Plate	Region	H. V. Mod.	Slit	Hole	Exp.	Comp. Spectrum		Temp.		Remarks	
											Red	Kind	Red	Kind		
78 <i>Sch.</i>	297	1899 Feb. 15	3 D. F.	1	C. I. L.	Y. G.	5.0	9.50	242	11	16	Fe Spark	+0.2	-3.0	fair	
132	298	" 23	"	1	"	"	5.0	10.35	245	10	15	"	-10.2	-8.8	poor	
132	300	May 5	"	1	"	"	4.0	10.32	165	10	8	"	-6.7	-10.0	"	
132	301	" 6	"	1	"	"	5.0	7.30	250	7	8	"	-6.3	-14.2	fair	
132	302	" 6	"	1	"	"	5.0	11.49	160	8	8	"	-14.2	-15.2	"	
132	307	" 25	"	1	"	"	5.0	16.03	110	8	8	"	-16.4	-16.4	"	
132	309	" 25	"	1	S. G. E.	Blue	5.0	11.45	335	8	8	"	-5.3	-8.3	"	
132	316	" 31	"	1	"	"	5.0	10.00	225	10	10	"	-6.4	-8.2	"	
132	319	April 12	"	1	"	"	5.0	12.15	300	7	9	"	-3.5	-7.0	good	
132	322	May 4	"	1	C. I. L.	Y. G.	10.0	9.47	30	10	10	"	+18.0	16.2	fair	
132	323	" 4	"	1	"	"	2.0	10.31	30	10	10	"	15.0	15.0	good	
132	324	" 4	"	1	S. G. E.	Blue	6.0	11.20	300	7	8	"	14.0	11.8	fair	
132	326	" 10	"	1	C. I. L.	Y. G.	5.0	9.30	1	1	1	"	15.0	15.0	"	
132	327	" 10	"	1	"	"	5.0	9.40	1	1	1	"	16.0	16.0	good	
132	328	" 10	"	1	S. G. E.	Blue	6.0	10.23	335	7	6	Fe Spark	14.5	10.0	"	
132	329	June 7	"	1	C. I. L.	Y. G.	5.0	8.20	432	7	7	"	20.0	15.7	"	
19 <i>Pisc.</i>	332	July 5	"	1	"	"	4.0	9.00	350	20	19	"	20.8	17.8	"	
19	334	Aug. 24	"	1	S. G. E.	Blue	4.0	13.10	165	24	23	Fe Spark	23.5	22.5	poor	
19	337	Sept. 13	"	1	"	"	5.0	12.08	120	3	10	"	14.2	12.2	"	
19	343	Oct. 4	"	1	"	"	4.0	9.03	250	4	3	"	14.8	12.0	good	
78 <i>Sch.</i>	344	" 4	"	1	"	"	1.15	E. 3.0	7.05	285	2	2	"	12.0	10.0	"
132	345	" 12	"	1	"	"	2.30	E. 4.5	12.15	310	2	2	"	12.0	10.0	"
289	346	" 18	"	0	Crown	"	1.00	W. 5.0	13.29	180	1	1	"	8.0	8.0	fair
19 <i>Pisc.</i>	355	Dec. 7	"	1	"	"	1.30	W. 5.0	10.08	200	1	1	"	3.8	2.0	"
132	356	" 18	1 L. F.	1	C. I. L.	Y. G.	1.10	W. 4.5	4.55	325	2	2	"	3.8	2.0	"
51 <i>Sch.</i>	358	" 19	3 D. F.	1	"	Blue	3.0	5.07	185	10	10	Fe Spark	9.0	3.8	good	
115	359	" 19	"	0	Crown	Blue	0.30	W. 4.5	9.20	280	8	8	"	-4.0	-5.4	poor
289	360	" 21	"	0	"	"	1.1	W. 4.5	15.00	210	1	1	Fe Spark	-5.5	-1.2	good
115	361	" 21	"	0	"	"	3.30	W. 5.0	5.56	420	1	1	"	+3.8	+1.2	good
51	362	" 26	"	0	"	"	1.20	W. 5.0	13.29	345	1	1	"	-1.2	-0.8	fair
115	363	" 26	"	0	"	"	5.2	E. 8	3.35	65	1	1	"	-9.0	-9.0	"
51	364	" 26	"	0	"	"	1.00	W. 6.0	12.25	330	1	2	"	-10.8	13.6	"
51	365	" 27	"	0	"	"	0.30	E. 5.0	7.18	310	1	1	"	-3.4	-10.0	"
289 <i>Sch.</i>	366	" 27	"	0	C. I. L.	Y. G.	1.45	W. 5.0	13.29	345	15	15	"	-19.5	-13.4	"
289	367	" 28	"	0	"	"	5.00	W. 6.0	5.59	555	10	15	"	-12.0	-16.2	"
289	368	" 29	"	0	Crown	Blue	4.00	W. 6.0	5.19	480	1	1	"	-14.0	-18.5	"
132	369	" 29	"	0	"	"	0.30	W. 5.0	13.42	315	2	2	"	-18.4	-19.0	"
19 <i>Pisc.</i>	369	" 29	1 L. F.	1	"	"	2.30	W. 5.0	5.55	185	1	1	"	-16.0	-18.5	"
289 <i>Sch.</i>	370	1900 Jan. 2	3 D. F.	1	C. I. L.	Y. G.	5.30	W. 6.0	5.07	650	10	10	"	-5.5	-6.2	good
51	371	" 7	"	1	Crown	Blue	1.10	E. 5.0	6.20	300	10	9	"	+2.0	7.7	fair
51	372	" 7	"	1	C. I. L.	Y. G.	5.0	7.21	300	10	9	"	+0.9	-0.5	good	
51	373	" 7	"	1	"	"	2.20	E. 5.0	6.20	300	8	7	"	+3.9	1.6	"
115	374	" 21	"	1	"	"	2.00	W. 5.0	12.48	310	7	7	"	-3.2	-2.2	"
51	375	" 21	"	1	Erythro	Y. R.	2.30	E. 6.0	10.43	340	300	240	"	-3.8	+1.6	fair
51	377	" 24	"	1	C. I. L.	Y. G.	0.15	E. 5.0	6.35	310	7	7	"	+5.2	4.3	"
51	378	" 25	"	1	"	"	1.20	E. 5.0	6.00	320	7	7	"	-10.0	-10.8	poor
51 <i>Pisc.</i>	379	" 25	"	1	"	"	0.40	W. 5.0	12.27	280	7	7	"	-14.0	-14.3	fair
289 <i>Sch.</i>	380	" 26	"	0	Crown	Blue	7.00	E. 5.0	13.45	365	1	1	"	-21.3	-21.0	"
115	382	" 31	"	0	"	"	1.40	W. 5.0	10.20	380	1	1	"	20.0	-22.0	"
51	383	Feb. 1	"	1	"	"	2.20	W. 5.0	8.30	350	14	14	"	14.0	14.0	good
78	384	" 9	"	1	C. I. L.	Y. G.	5.0	10.15	250	7	13	"	12.0	11.8	poor	
289	385	" 15	"	0	Crown	Blue	2.30	W. 5.0	6.15	330	7	13	"	16.0	18.5	"
78	386	" 16	"	1	C. I. L.	Y. G.	2.15	W. 5.0	6.45	255	7	6	"	-17.0	-18.3	fair
78	387	" 19	"	1	"	"	0.30	W. 5.0	7.00	185	6	11	"	-7.0	-7.4	"
289	388	" 25	"	0	Crown	Blue	8.00	W. 5.0	6.20	360	1	1	"	-12.0	-16.8	good
51	389	March 6	"	1	"	"	2.20	W. 5.0	6.10	340	4	12	"	-7.0	-9.2	"
51	391	" 7	"	1	"	"	2.20	W. 5.0	6.22	380	3	12	"	-3.0	-4.1	"
78	392	" 21	"	1	"	"	2.45	W. 5.0	6.47	315	1	1	"	-0.5	-0.1	fair
51 <i>Birm.</i>	393	" 31	"	1	"	"	2.15	W. 5.0	10.45	320	1	1	"	+2.8	2.8	"
132	394	April 4	"	1	"	"	2.40	W. 4.0	11.55	340	1	1	"	+4.0	2.9	good
289	395	April 8	"	1	C. I. L.	Y. G.	4.0	9.20	330	6	6	"	28.8	24.8	"	
289	396	" 19	"	1	"	"	2.40	W. 4.2	12.37	243	6	6	"	26.0	24.9	"
132	397	" 26	"	1	"	"	3.2	12.32	135	5	6	"	19.6	18.7	"	
289	398	" 31	"	1	"	"	4.3	8.20	145	5	6	"	25.0	23.4	"	
132	418	1901 April 8	"	1	Erythro	Y. R.	2.40	W. 5.0	11.41	300	240	180	H Tube	3.0	3.0	"
229	450	Oct. 24	"	1	Crown	Blue	1.00	W. 4.0	7.40	360	15	2	Fe Spark	11.9	11.9	fair
132	451	Feb. 10	"	"	27 G. E.	"	2.50	E. 4.1	9.15	360	2	2	Fe Spark	-7.4	-7.3	good
132	452	" 18	"	"	"	"	3.00	E. 4.0	8.25	380	2	2	"	-6.8	-6.9	good
132	453	" 21	"	"	"	"	1.1	E. 3.0	5.30	320	4	12	"	-1.2	-1.2	good
19 <i>Pisc.</i>	454	Oct. 19	1 L. F.	1	C. I. L.	Y. G.	1.00	E. 3.0	10.19	180	4	10	"	-1.2	-1.2	24 inch Reflector
19	455	" 24	"	0	"	"	4.0	6.50	320	30	15	"	10.0	10.0	fair	
19	456	" 24	"	0	"	"	4.0	6.50	320	30	15	"	10.0	10.0	"	
19	457	Nov. 18 to 23	"	0	"	"	4.0	5.55	4.5	1	1	"	10.0	10.0	good	
19	458	"	"	0	"	"	5.0	6.8	1480	1	1	"	10.0	10.0	fair	

Seed's Gilt Edge (S. G. E.) plates were also used in some cases. The slit-width is expressed in divisions of the head: one division = 0.025 mm. A spark between iron poles was usually employed for the comparison spectrum, part of the exposure being given before, part after, the exposure for the star. A titanium spark was used in the later work. The temperature in the prism box was recorded at the beginning and at the end of the exposure. Most of the exposures were made by Mr. Ellerman.

## APPEARANCE OF THE SPECTRA ON THE PHOTOGRAPHS

The spectra were photographed in four sections, as follows:

1.  $\lambda$  3930 to  $\lambda$  4380. These photographs were taken on Seed 27 non-halation plates with a single light flint prism and a camera of 151 mm. focal length, used in conjunction with the two-foot reflector. They were made for the special purpose of showing the very faint region in the extreme violet part of the spectrum, and some of them are therefore overexposed in the blue.

2.  $\lambda$  4380 to  $\lambda$  4980. Most of these photographs were taken with three dense flint prisms and a camera of 271 mm. focal length. Cramer Crown plates were usually employed. With the aid of the correcting lens, the color curve of the forty-inch objective, which is very steep in this region, was flattened out sufficiently to give fairly uniform illumination through the middle part of the spectrum. At both ends, however, the brightness falls off somewhat on account of the change in focus. In the less refrangible region these spectra are further weakened by the fact that the plates are relatively insensitive for light of these wave-lengths. It will be seen from these and other facts that the region of the spectrum lying between  $\lambda$  4900 and  $\lambda$  5160 is not well represented on most of our photographs.

3.  $\lambda$  5160 to  $\lambda$  5800. The greater part of these photographs were taken with three dense flint prisms and a camera of 271 mm. focal length on Cramer isochromatic plates. As already remarked on p. 7, the form of the color curve of the forty-inch objective and the fall in sensitiveness of the plates in this region cause these photographs to be relatively underexposed at the more refrangible end, though the focus was set for  $\lambda$  5000. Little is shown beyond  $\lambda$  5800, as the isochromatic plates decrease rapidly in sensitiveness in this region.

4.  $\lambda$  5630 to  $\lambda$  6600. Photographs of the spectra of 152 *Schjellerup* and 19 *Piscium* were obtained in this region with a single dense flint prism and a camera of 508 mm. focal length on Erythro plates.

In studying the photographs, it is necessary to bear in mind the fact that the various adjustments required in photographing the spectra in sections necessarily introduce differences of relative intensity, and render it almost impossible to determine accurately the distribution of brightness throughout the spectra. In the following description of the photographs it is to be understood, therefore, that the appearances described relate to the plates themselves, and not to the spectra as seen visually in a telescope.

*General characteristics.*—The most striking features of spectra of the fourth type are the dark bands attributed to the compounds of carbon. The principal bands have their less refrangible edges at  $\lambda$  4737.8,  $\lambda$  5167.9, and  $\lambda$  5636.9. Bright zones, consisting of bright lines and strong continuous spectrum, appear on our plates on the less refrangible side of the first and last of these heads;<sup>13</sup> and bright and dark lines are found in connection with the continuous spectrum throughout the region photographed. The fluted character of the carbon bands is strikingly evident in the region  $\lambda$  5500– $\lambda$  5637, especially in such stars as 132 *Schjellerup*; it also appears in the other carbon bands when the exposures are suitable, and in the cyanogen band at  $\lambda$  4502– $\lambda$  4606 (see Plate VII).

*Details.*—The violet region of the spectra of fourth-type stars is so faint that it can be photographed only with the greatest difficulty. On account of the form of the color curve and the absorption in the violet of the forty-inch objective, no attempt was made to include the extreme violet on plates taken with the large refractor. It was nevertheless deemed of great importance to determine whether the H and K lines and the *H $\gamma$*  and *H $\delta$*  lines were present, and also to render possible the comparison of fourth-type with third-type spectra in the violet region. For this reason a few photographs of the spectra of 19 *Piscium* were made, as described above, with the two-foot reflector. The most prominent features of these photographs are the very strong calcium line at  $\lambda$  4227 and the H

<sup>13</sup> The brightness of the region on the less refrangible side of the carbon head at  $\lambda$  5167.9 is reduced on our photographs for the reasons given above.

and K bands, which are very conspicuous. Less prominent, but nevertheless unmistakable, are the dark hydrogen lines  $H\gamma$  and  $H\delta$ , as well as the G group and two conspicuous lines at  $\lambda 4058$  and  $\lambda 4384$  (Figs. 1 and 2, Plate X).

The presence of dark  $H\gamma$  and  $H\delta$  lines renders the existence of a bright  $H\beta$  line in the photographs taken with three prisms a matter of great interest. The comparatively large scale of these spectra and their sharpness of definition leave no doubt as to the presence and identification of lines in this region. In two or three stars  $H\beta$  appears as a bright line, and in this character it is the most striking feature of the spectrum of 280 *Schjellerup*. In several of the stars, however,  $H\beta$  is altogether absent, and in no case do we find it present as a dark line. The bearing of these results on the physical condition of hydrogen in the fourth-type stars is discussed elsewhere (p. 126).

The cyanogen flutings, with heads at  $\lambda\lambda 4608.9, 4578.4, 4553.3, 4515$ , and  $4503.2$ , are characteristic features of all the fourth-type spectra we have examined, including 280 *Schjellerup*. In each fluting the continuous spectrum grows stronger toward the blue, but the bright lines in this region are scattered with less regularity than in the yellow flutings. From the more refrangible edge of the bright blue zone at  $\lambda 4738.6$  the continuous spectrum, here of maximum brightness, gradually decreases in intensity toward  $\lambda 5000$ . Between this zone and the head of the dark carbon band at  $\lambda 4737.8$  there are two unidentified flutings in the spectrum of 152 *Schjellerup*, but in most of the other stars only one of these flutings appears. The most prominent dark lines are those at  $\lambda\lambda 4408, 4435, 4497, 4506, 4523$ , and  $4535$ . Between  $\lambda 5000$  and  $\lambda 5169$  the carbon absorption is nearly complete, and for various other reasons already given few details are shown in our photographs of this region. Nevertheless, the carbon heads at  $\lambda 5099$  and  $\lambda 5129$  can be recognized in 229 *Schjellerup* (Fig. 1, Plate VII).

In the green and yellow the continuous spectrum decreases in intensity from the maximum near the  $b$  group and attains its minimum brightness in the absorption of the yellow carbon bands. These flutings have heads at  $\lambda\lambda 5638.8, 5587.7$ , and  $5505.5$ , and form the most characteristic feature of the spectrum. Each is made up of bright and dark lines, the bright lines being strongest at the more refrangible part of each fluting, while the dark lines are broadest and strongest at the less refrangible edge. For various reasons, discussed elsewhere, this effect, in some cases, at least, appears to be due to the presence of genuine bright lines, and not merely to contrast. Other bright lines, the character of which cannot be doubted, occur in the green region, where they are very conspicuous on the original negatives. The bright yellow zone also contains a large number of bright lines, lying on a less brilliant background of continuous spectrum. In 280 *Schjellerup* the bright lines are inconspicuous. The broad dark line  $\lambda 5620-5638$  is double, and the component  $\lambda 5620-5626$  contains three vanadium lines. In 280 *Schjellerup* this double line is the only well-marked trace of the yellow carbon band. In 19 *Piscium* the entire set of flutings is easily recognized, and they increase in intensity as we pass to 318 *Birmingham*, 74, 78, and 132 *Schjellerup*, while in 152 *Schjellerup* they are less noticeable, apparently from increased carbon absorption, which cuts down the contrast. The most conspicuous dark lines in this part of the spectrum have the wave-lengths  $\lambda\lambda 5226, 5329, 5350, 5371, 5397, 5410$ , and  $5447$ . The last pair of lines has a curious appearance, resembling that of a symmetrical reversal. The  $b$  lines are conspicuous in all of the stars. In the more fully developed stars the group  $\lambda 5204-5211$  becomes the most prominent feature in this part of the spectrum. The  $b$  group also becomes stronger, but  $b_3$  and  $b_4$  are nearly lost in the carbon absorption band whose head is at  $\lambda 5169.1$ .

The more refrangible part of the spectrum is shown in a few photographs obtained with Erythro plates. The D line appears strong and dark, but it is not divided, as the plates were taken with one prism. The continuous spectrum is fairly strong from the sodium line to a dark line at  $\lambda 5732$ , which separates this part from the bright yellow zone,  $\lambda 5637-5726$ . In the region  $\lambda 6086-6340$  the bright lines and strong continuous spectrum form a bright zone. There are two unmistakable bright lines at  $\lambda 6176$  and  $\lambda 6201$ , and also two which are less certainly bright at  $\lambda 6105$  and  $\lambda 6131$ . There

is a strong bright line at  $\lambda$  6270, and two or three probably bright lines in the interval  $\lambda$  6275-6340. There is also a dark line at  $\lambda$  6358. At  $\lambda$  6445 there is possibly a bright line. From this point the continuous spectrum greatly decreases in intensity until its limit is reached at  $\lambda$  6600 (Fig. 1, Plate VI).

Certain peculiarities in the spectrum of 152 *Schjellerup* are referred to on p. 131.

#### THE PRESENCE OF BRIGHT LINES

In his memoir *Sugli Spettri Prismatici delle Stelle Fisse*, and in his treatise *Le Soleil*, Secchi refers in several places to the existence of bright lines in the spectra of fourth-type stars:

Non mancano in queste stelle (152 *Schjellerup*) delle righe brillanti come le metalliche, ed è singolare che esse si mostrano nella estrema più viva delle zone colorate. Gli spettri di queste stelle hanno più che gli altri analogia coi gas, e specialmente con quello del carbonio, ma rovesciato.<sup>14</sup>

Avvertimmo già che in alcune vi sono delle righe vive assai simili alle metalliche, le quali spiccano assai; alcune nel giallo paiono fili d'oro.<sup>15</sup>

Such references would seem to leave no doubt that Secchi saw some of the bright lines whose existence is shown by our photographs. His intensity curve of the spectrum of 78 *Schjellerup* (Fig. 1)<sup>16</sup>

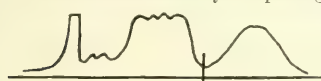


FIG. 1

places two of the bright lines in the yellow not far from their true positions, though the less refrangible of these two lines should be given much greater intensity than the more refrangible one. But the illustration of the spectrum of the same star published later by

Secchi in the second edition of *Le Soleil* (Plate M) contains no bright lines, while the drawing of the spectrum of 152 *Schjellerup* in the same plate shows two narrow bright lines in each of the three bright zones, but omits the strong bright lines in the yellow carbon band. Moreover, in describing the spectrum of 132 *Schjellerup*, Secchi remarks:

Tipò 4° ben deciso con due forti righe lucide nel giallo assai vive e che sono da misurare se fosse il sodio.

Other intensity curves given by Secchi show, as Dunér has pointed out in his memoir,<sup>17</sup> that in some cases the supposed bright lines probably refer to the broad yellow sub-zone, the width of which is not less than ninety tenth-meters. Thus in describing the spectrum of 136 *Schjellerup*, whose intensity curve is reproduced in Fig. 2 from the *Memoria Seconda*, p. 44, Secchi remarks:



FIG. 2

Lo spettro è analogo alla 132, ma in parte diverso: ha una forte riga doppia viva nel giallo, poi segue una zona scura.

As Dunér states:

Secchi s'est plus tard persuadé, par des mesures, que les deux raies jaunes n'ont pas la même position que celles du sodium, mais il est néanmoins difficile de comprendre comment il a pu croire que cette zone, quarante fois plus large que la distance entre  $D_1$  et  $D_2$ , fût les raies du sodium.

On the whole, it is hardly probable that Secchi actually distinguished the true bright lines, though he was so much impressed by the appearance of the bright zones that he remarked:<sup>18</sup>

Le spectre dans son ensemble se présente comme un spectre direct appartenant à un corps gazeux, plutôt que comme un spectre d'absorption.

In this connection it is an interesting fact that Pickering in his early visual surveys of stellar spectra states that a normal fourth-type spectrum "consists of a well-defined yellow band, a broad green band well defined on the more refrangible side and generally less sharply bounded on the other, and a blue band in some cases well defined toward the violet."<sup>19</sup>

<sup>14</sup> *Memoria Seconda*, p. 9.

<sup>15</sup> *Ibid.*, p. 12.

<sup>17</sup> *Loc. cit.*, p. 10.

<sup>18</sup> *Le Soleil* (2d ed.), Vol. II, p. 458.

<sup>19</sup> *A. N.* 2376.

<sup>16</sup> Reproduced from his *Memoria Seconda*, p. 40; the red end of the spectrum is at the left.

Dunér quotes Secchi's statements regarding bright lines in his memoir,<sup>17</sup> but states that he has never seen the least thing which could explain Secchi's belief in bright lines, and remarks that Vogel was not more fortunate. At that time he also considered that the spectrum was incontestably an absorption spectrum, and Vogel entertained the same view:

Es stellt sich unzweifelhaft heraus, dass die Discontinuität des Spectrums nur eine scheinbare ist, hervorgebracht durch breite Absorptionsbanden.<sup>20</sup>

More recently, Dunér has observed the spectra of these stars with a telescope having a Steinheil visual objective of 36 cm. aperture, and remarks: "Of first importance is the fact that I was able to detect without difficulty bright lines in various spectra which at Lund were either invisible or at least could not be discovered."<sup>21</sup> The detailed observations given in this paper show that a bright line (probably the one at  $\lambda$  5592) was seen by Dunér in the spectra of all of the brighter stars.

Our earliest photographs of the spectra of fourth-type stars, made before the publication of Dunér's second paper, seemed to show without question the presence of bright lines. But as Dunér had expressed so decided an opinion against their existence, and as his conclusions had been supported by the results of Vogel's observations, it seemed desirable to undertake a series of tests for the purpose of meeting any doubts that might arise.

As shown on the photographs, the numerous bright lines in these spectra appear decidedly stronger than the continuous spectrum in their neighborhood, and prove their superior brightness by extending out on either side of the general spectrum, thus showing their power of impressing the plate at points where the continuous spectrum was too faint to do so. The evidence thus afforded as to the genuineness of the bright lines is not preserved in the widened photographs of the plates, but is fairly well shown in a direct enlargement of the spectrum of 132 *Schjellerup* reproduced in Plate V.

The following tests were employed to determine the genuineness of the bright lines:

1. It was found that an exposure of four minutes was sufficient to photograph the bright line at  $\lambda$  5592 in the spectrum of 152 *Schjellerup* with a dispersion of three prisms, while equal density of the contiguous spectrum could not be obtained under the same conditions with an exposure of less than from twelve to fifteen minutes. If the line is supposed to be due to the continuous spectrum, it must be assumed that the heavy carbon absorption band is interrupted at this point. It is true that the line falls close against the second head of the fluting, and therefore at a point where the absorption band would be weakest. But the bright line appears to be sharply bounded on both sides, whereas it should fade away gradually toward the red if it were due to decreased absorption.

2. By increasing the dispersion an apparent bright line, if really due to continuous spectrum bounded by portions of the carbon absorption band, should be rendered less conspicuous. In our experiments it was found, however, that the contrast between the bright lines and the contiguous spectrum increased rather than diminished with the dispersion, and that the lines were best observed both visually and photographically with our most powerful combination of three heavy flint prisms.

3. Similarly, an increase in slit-width should tend to reduce the contrast if the effect were due to continuous spectrum bounded by dark lines or bands. In practice, however, the bright lines were admirably shown with the widest slits, and increase of slit-width did not seem to reduce the contrast.

Although there can be no doubt as to the presence of iron and other metals in these stars, it will be seen from inspection of the detailed comparisons on pp. 117-22 that many of the strong lines of these substances are absent. A large part of these can be accounted for, however, if it is assumed that they are hidden by overlying bright lines.

Photographic observations alone were not allowed to settle the matter, and on many occasions the spectra of 132 *Schjellerup* and 152 *Schjellerup* were examined visually with the three-prism spectroscopic telescope attached to the forty-inch telescope. With an observing telescope having a focal length of 253 mm. and an eyepiece magnifying thirteen diameters, the bright line at  $\lambda$  5592 was easily seen,

<sup>17</sup> *A. N.* 1009.

<sup>21</sup> "On the Spectra of Stars of Class IIIb," *Astrophysical Journal*, Vol. IX, 1896, p. 121.

as well as a number of other bright lines in the red, yellow, green, and blue. Under the same circumstances some of the more conspicuous dark lines were seen without much difficulty, but the less conspicuous ones were not visible.

As a further precaution, we requested Professors Keeler and Campbell to observe the spectrum of 152 *Schjellerup* with the thirty-six-inch refractor of the Lick Observatory. They did so, using a dispersion of three prisms, and Professor Keeler reported his observations as follows:

I compared the spectrum with Vogel's drawing in *Potsdam Publications*, Vol. IV. The drawing seemed to be merely a rough indication of what the spectrum actually is. What we saw was much more like your photograph. It is curious that Vogel did not see the bright line  $\lambda 550 \pm$ , as it is a conspicuous feature of the spectrum with the thirty-six-inch. The bright block  $\lambda 553 - \lambda 584$  seems to be a complex of bright and dark lines or bands, and the dark band as shown in the drawing ( $\lambda 573$ ) is relatively too conspicuous. Vogel's dark band at  $\lambda 525$  is made up of lines, of which there are many in the neighborhood. There is a strong line at or near D. We tried to identify it with the *Na* line in a spirit lamp, but the telescope was jumping in a high wind, and the comparison did not amount to much. There were many dark lines in the red.

To my mind, there is little doubt that the spectrum of this star contains bright lines.

These results are in striking contrast with those obtained by Sir Norman Lockyer, and reported by him in his article, "The Piscian Stars".<sup>22</sup>

The Kensington observations were made chiefly during 1894 and 1895, with special reference to the lines involved. The stars selected for observation were 132 *Schjellerup*, 152 *Schjellerup*, 115 *Schjellerup*, and 19 *Piscium*. The 3-foot reflector was used. In addition to the carbon bands, numerous lines were seen without much difficulty, but only the more prominent ones could be satisfactorily measured. Among the lines recorded in 132 *Schjellerup* were *H $\beta$* , the E line of iron at 5269, and a group of lines near  $\lambda 5380$ . In 115 *Schjellerup* additional lines were measured near 5005, 5762, and 5429, and the presence of *H $\beta$*  was again determined by comparison with a hydrogen vacuum tube. In 19 *Piscium* numerous lines were observed, among them being D and F. No suspicion of bright lines was entertained during these observations. Attempts to photograph the spectra were not sufficiently successful to help matters.

A three-foot reflector should be admirably adapted for the investigation of these stars, whether visually or photographically. And yet the bright lines, which should have been easily visible, were not seen, while *H $\beta$*  was recorded as a dark line in 132 *Schjellerup*, 115 *Schjellerup*, and 19 *Piscium*. As a matter of fact our photographs show no dark *H $\beta$*  line in any of these stars.

In discussing the probability of the existence of bright lines on our photographs, Lockyer was at a disadvantage, as he had not seen the original negatives, and the few published reproductions did not adequately represent the facts. As Fig. 3, Plate V, shows, the bright lines are distributed all through the spectrum, and are by no means confined to the edges of flutings, where Lockyer thinks contrast effects would sufficiently account for the appearance of the photographs.<sup>23</sup>

In the table of mean wave-lengths (p. 92), which contains 213 bright lines, we have included only those lines which were regarded as unquestionably bright by at least two independent observers. In some cases, where the brightness of the line is but very little greater than that of the continuous spectrum, there might easily be some room for doubt, and many lines of this character have accordingly been excluded from the table. In many other cases, on the contrary, the bright lines are so much stronger than the continuous spectrum that the most critical observer of the original negatives would not hesitate for a moment to distinguish them from mere spaces between dark lines. We may add that the judgment of a large number of spectroscopists who have examined the negatives coincides entirely with our own.

#### MEASUREMENT OF THE PHOTOGRAPHS

As it seemed more important, in the existing state of the subject, to examine thoroughly a small number of photographs than to study a large number of spectra less completely, the following plates were selected for detailed measurement:

<sup>22</sup>*Proc. Roy. Soc.*, Vol. LXVI, p. 137.

<sup>23</sup>The bright lines are unduly conspicuous in Fig. 2, Plate VI, as the contrast of the plate was increased in copying.

## LIST OF PLATES MEASURED

Star	Plate	Date			G. M. T.		Exp.	Hour-angle	Qual.	Comp. Spec.	
		y	m	d	h	m				Kind	Qual.
19 <i>Pisium</i> .....	G 259	1898	12	29	11.6	50	W 0.6	C		Fe	B
	G 264	1898	12	31	12.5	180	W 1.6	C-B		Fe	C
	G 269	1899	1	6	12.3	115	W 1.9	A		Fe	C
	G 293	1899	1	27	13.0	125	W 3.9	A-B		Fe	B
	G 343	1899	10	4	15.5	285	E 1.3	B		Ti	A
	G 357	1899	12	19	12.8	195	W 1.2	A		Ti	A
	R 34	1902	10	19	15.6	330	E 0.3			Moon	
	R 37	1902	10	30	15.8	465	W 0.7			Sky	
				18							
	R 38	1902	11	19	15±	1480	0 ±			Sky	
				22							
				23							
280 <i>Schjellerup</i> .....	G 346	1899	10	18	16.1	200	W 1.5	C		Ti	B
	G 366	1899	12	28	11.6	565	W 5 ±	B-C		Ti	B
	G 367	1899	12	29	11.2	480	W 4 ±	C		Ti	B
	G 370	1900	1	2	11.1	660	W 5.5	C		Ti	B
318 <i>Birmingham</i> .....	G 253	1898	12	26	21.7	240	E 0.5	B		Fe	B
	G 276	1899	1	15	16.4	360	E 4.4	B		Fe	B-C
	G 284	1899	1	20	17.8	255	E 2.7	B		Fe	B-C
	G 379	1900	1	25	20.7	280	W 0.4	C-B		Ti	B
	G 393	1900	3	31	18	220	W 2.2	A		Ti	B
74 <i>Schjellerup</i> .....	G 373	1900	1	7	15.0	300	E 2.1	A-B		Ti	B
	G 383	1900	2	1	17.3	370	W 1.8	C		Ti	C
	G 386	1900	2	16	14.8	255	W 0.3	C-D		Ti	B
	G 391	1900	3	7	15.5	380	W 2.3	B		Ti	B
78 <i>Schjellerup</i> .....	G 300	1899	3	6	14.8	250	W 2.0	B		Fe	B
	G 344	1899	10	4	20	310	E 2.8	B		Ti	A
	G 384	1900	2	9	18.4	290	W 2.9	B		Ti	B
	G 392	1900	3	21	18	315	E 2.9	A		Ti	B
132 <i>Schjellerup</i> .....	G 299	1899	3	5	17.8	165	W 0.3	B		Fe	B-C
	G 301	1899	3	6	19.0	160	W 1.5	A		Fe	A
	G 309	1899	3	23	17.8	225	W 1.4	B-C		Fe	B-C
	G 368	1899	12	29	22.1	315	W 0.2	C-B		Ti	C-B
	A 328	1902	2	21	18.3	330	E 0.7	A		Ti	A-B
115 <i>Schjellerup</i> .....	G 363	1899	12	26	21.0	330	W 1.0	C-D		Ti	C
	G 365	1899	12	27	21.8	305	W 1.8	B		Ti	C
	G 374	1900	1	7	20.5	310	W 2.3	B		Ti	B
	G 382	1900	1	31	19.3	380	W 1.7	B-C		Ti	B-C
152 <i>Schjellerup</i> .....	G 275	1899	1	14	22.2	119	E 0.8	A		Fe	B
	G 291	1899	1	26	20.8	135	E 1.3	B		Fe	
	G 302	1899	3	6	22.8	110	W 3.3	A		Fe	A-B
	G 316	1899	3	31	20.7	300	W 2.7	B		Fe	B
	G 394	1900	4	4	17.3	300	E 2.7	A		Ti	B
	A 313	1902	2	10	18.3	360	E 2.8	B		Ti	B
	A 319	1902	2	18	17.7	380	E 3.0	A		Ti	A-B
	G 211	1898	7	1	17.4	350	W 5.5			Fe	

The other photographs, which include many excellent spectra, were used for general study and comparison.

The scale of the spectra is given in the following table:

SCALE OF THE PLATES  
I. PLATES TAKEN WITH THREE PRISMS  
(Camera I)

BLUE REGION		YELLOW-GREEN REGION		
Wave Length	$\frac{d\lambda}{\lambda}$	Wave Length	$\frac{d\lambda}{\lambda}$	
4100	0.054	5200	0.025	End of spectrum
4700	0.036	5500	0.019	Middle of spectrum
5000	0.026	5800	0.015	End of spectrum

SCALE OF THE PLATES—*Continued*

## II. PLATES TAKEN WITH ONE PRISM

BLUE REGION (Camera 0)		RED REGION (Camera 2)		
Wave-Length	$\frac{ds}{d\lambda}$	Wave-Length	$\frac{ds}{d\lambda}$	
4000	0.010	5800	0.011	End of spectrum
4200	0.008	6200	0.009	Middle of spectrum
4400	0.006	6600	0.007	End of spectrum

The three prisms of the old spectrograph have a visual resolving power of about 33,000 for  $\lambda$  4860, but with the slit-widths employed in the present investigation only a small fraction of this is realized. In the region near  $\lambda$  4400 it is possible to separate on the photograph lines 0.8 tenth-meter apart, while at  $\lambda$  5600 lines 1.3 tenth-meters apart are resolved.

With the Bruce spectrograph (camera A), which was used in a few cases, the scale is:

Wave-Length	$\frac{ds}{d\lambda}$
4400	0.084
4700	0.036
5000	0.026

*Method of measurement.*—Four different machines were used in the measurements: the Zeiss comparator, described in our earlier paper;<sup>24</sup> two similar machines, Nos. 122 and 873; and the Gaertner measuring machine, described by Messrs. Frost and Adams.<sup>25</sup> Careful investigations have shown that the scale errors of the Zeiss comparators and the errors of the screw of the measuring machine are of the same order, not exceeding  $2\mu$  or  $3\mu$ . With narrow slits and spectra better defined than those here available such errors would enter appreciably. We have found it sufficient, however, to eliminate the errors as far as possible by measuring the plates at four different parts of the screw or scale and adopting the mean as the true position of the line. No difference in treatment is required for the measurements of the different machines, as the same methods were used in all cases to eliminate errors. All of the measures given in this paper (excepting those of G 211, by Mr. Ellerman) were made by Mr. Parkhurst.

The plates were adjusted on the sliding stage of the machine so that the length of the spectrum was parallel to the scale (or screw), and the cross-hair in the microscope eyepiece was made parallel to the spectral lines. Four settings were made on standard lines of the comparison spectrum, two on the lines above the star spectrum, followed by two on the lines below. For the first few plates four settings were made on the star lines, but this number was afterward reduced to three. The average number of standard lines measured on each plate was thirteen. In order to test the stability of the plate on the machine these standards were generally measured both before and after the settings were made on the star lines. A single cross-hair, running entirely across the field of the microscope, was used throughout the measures. Each plate was measured in two positions on the machine, red end toward the right and left, respectively, and the mean of the results was used.

## REDUCTION OF THE MEASURES

We have described in a previous article<sup>26</sup> the various methods of reduction tried before we finally adopted the plan described in the present paper. These involved graphical methods, in which an interpolating machine devised for the purpose was employed, and a least-squares method based upon the use of the valuable Cornu-Hartmann interpolation formula. The results obtained by the least-squares method were entirely satisfactory, but considerable time was required to compute the

<sup>24</sup> GEORGE E. HALE AND FERDINAND ELLERMAN, "On the Spectra of Stars of Secchi's Fourth Type. I," *Astrophysical Journal*, Vol. X (1899), p. 102.

Twenty Stars having Spectra of the Orion Type," *Publications of the Yerkes Observatory*, Vol. II, p. 148.

<sup>26</sup> GEORGE E. HALE AND FERDINAND ELLERMAN, *loc. cit.*, p. 103.

<sup>25</sup> EDWIN B. FROST AND WALTER S. ADAMS, "Radial Velocities of

constants of the formula in this way. For this reason the least-squares solution was replaced by a residual-curve method, which furnished an equally satisfactory means of correcting the approximate constants and required far less time. This method is described in the present paper.

The combination of red-right and red-left measures was effected by subtracting the mean of the red-left measures from a constant so chosen as to make the difference about equal to the mean of the red-right measures. The final mean of this difference and the mean of the red-right measures was taken as the quantity  $s$  in the Cornu-Hartmann formula

$$\lambda = \lambda_0 + \frac{c}{s - s_0},$$

in which  $s$  is the mean scale reading,  $\lambda_0$ ,  $c$ , and  $s_0$  constants derived by substituting the scale readings of three standard lines for  $s$  and solving the three resulting equations, and  $\lambda$  is the desired wave-length. The derivation of the constants and the solution of the equation for the wave-length of each star line was greatly facilitated by the use of the Brunsviga calculating machine.

*Reduction to the Sun.*—The correction for the Earth's orbital velocity was made by the use of formulae given by Dr. Schlesinger,<sup>27</sup> where we may put:

$$\begin{aligned}\tan \lambda &= [9.96255] \tan \alpha + [9.59987] \sec \alpha \tan \delta \\ b &= [1.47371] \sec \lambda \cos \alpha \cos \delta \\ c &= [8.224] b \sin (281^\circ 20' - \lambda).\end{aligned}$$

For 1900 we obtain the following constants for reduction to the Sun:

Star	R. A.	Dec.	Long.	Log $b$	$c$
74 Schjellerup.....	6 19 46	+ 11 46.6	91 50	1.4689	- 0.06
78 Schjellerup.....	6 29 40	+ 38 31.6	96 04	1.4539	- 0.04
115 Schjellerup.....	8 49 45	+ 17 36.7	130 03	1.4734	+ 0.24
132 Schjellerup.....	10 32 36	- 12 51.9	164 53	1.4456	+ 0.42
318 Birmingham	10 38 08	+ 67 56.2	125 44	1.2538	+ 0.01
152 Schjellerup.....	12 49 26	+ 45 59.2	165 34	1.3227	+ 0.32
19 Piscium.....	23 41 17	+ 2 56.0	356 42	1.4733	- 0.50
290 Schjellerup..	23 56 10	+ 59 47.9	33 45	1.2555	- 0.28

The correction to the wave-length of the star lines was then

$$\Delta \lambda = V_a \left( \frac{\lambda}{299850} \right).$$

Instead of applying this correction separately to each wave-length derived from the formula, it was combined in the following manner with the correction curve which is required when the formula is used in its approximate form, without the exponent of the denominator  $(s - s_0)$ :

*Correction curve.*—An average of thirteen standard lines were measured in the comparison spectrum on each plate. With the exception of the three lines used in deriving the constants of the formula, each line gave a correction required to reduce its wave-length given by the formula to the standard wave-length. These corrections were plotted on squared paper, as shown in Fig. 3, in which the abscissae are wave-lengths given by the formula (scale, one square equals 10 m.) and the ordinates are the corrections (scale, one square equals 0.01 m.). A smooth curve, shown by the dotted line, was drawn through these points, from which corrections could be read off for each star line. The correction required for reduction to the Sun was then laid off on the same scale as the correction curve. This is a straight line located by the values for two arbitrarily chosen wave-lengths,  $\lambda$  4400 and 5000. The final correction curve, shown by the full line, was then drawn, making its ordinates the algebraic sum of the ordinates of the first curve and the reduction to the Sun. From this curve corrections were taken out and applied to the wave-length given by the formula for each star line. The correction for diurnal motion of the observer amounted to 0.005 m. only in the case of one plate, G 293 for 19

<sup>27</sup> *Amer. Rep. of Observat.* Vol. 8, 1896, p. 2.

*Piscium*, and as only two decimals were considered in the reductions, the diurnal correction was neglected for the other plates.

*Combination of results.*—The negatives taken on ordinary plates covered the region  $\lambda$  4370–4980; those taken on isochromatic plates,  $\lambda$  5170–5850. For convenience these will be called the blue and yellow-green regions, respectively. At least two plates of a region were measured for each star,

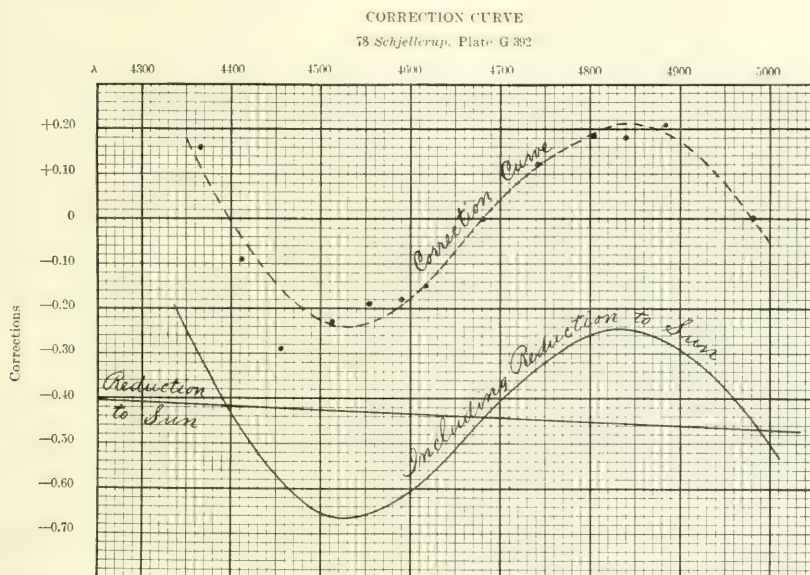


FIG. 3

and more than two if the quality of the plates required. In the case of lines measured on both plates, the mean of the results was taken as the wave-length of the line in that star, but for lines measured on only one plate the wave-length was reduced to the system of the two plates by adding to it the mean difference between the wave-lengths of the lines common to both. In the case of stars for which three or more plates were measured, the uncorrected means of the measures were taken. We thus have the following table of corrections to wave-lengths of lines found on only one plate:

CORRECTIONS TO WAVE-LENGTHS OF LINES FOUND ON ONLY ONE PLATE

Star	Region	Corrections	Basis
19 <i>Piscium</i> .....	blue	Mean = 264 - 0.06 = 343 + 0.06	76 lines
280 <i>Schjellerup</i> .....	{ blue	Mean = 346 + 0.09 = 367 - 0.08	24 lines
	{ yellow-green	Mean = 366 + 0.23 = 370 - 0.23	39 lines
318 <i>Birmingham</i> ....	blue	Mean = 276 + 0.03 = 393 - 0.03	57 lines
74 <i>Schjellerup</i> .....	{ blue	Used only one plate, G 391	
	{ yellow-green	Mean = 373 - 0.20 = 386 + 0.20	44 lines
78 <i>Schjellerup</i> .....	{ blue	Mean = 344 + 0.20 = 392 - 0.20	74 lines
	{ yellow-green	Mean = 300 + 0.06 = 384 - 0.06	63 lines
132 <i>Schjellerup</i> .....	yellow	Mean = 301 + 0.10 = 299 - 0.10	62 lines
115 <i>Schjellerup</i> .....	{ blue	Mean = 368 - 0.02 = 382 + 0.02	16 lines
	{ yellow-green	Mean = 365 + 0.02 = 374 - 0.01	64 lines
152 <i>Schjellerup</i> .....	yellow-green	Mean = 302 + 0.06 = 275 - 0.06	90 lines

*Exceptions to the adopted methods.*—The reductions for the six plates of 19 *Piscium* were carried out separately for the measures "red right" and "red left," and the means taken of the resulting wave-lengths, after which the correction for radial velocity was applied. To apply the correction curve to fit the formula to the wave-lengths of the standard lines, somewhat different methods were used for the first eight plates measured, six of 19 *Piscium*, and plate G 275 of the yellow-green region of 152 *Schjellerup*. On account of the poor quality of the standard lines and the effect of a neighboring air-line on the wave-length of the iron standard at  $\lambda 5710.75$ , the true form of the correction curve for the spectrograph was masked. The frequent appearance of an air-line close to the line mentioned shifted the center from one to two tenth-meters capriciously. After this was recognized this line was no longer used in deducing the constants of the formula. To avoid re-reduction, after the true form of the correction curve was found, a second curve was drawn, and from it were taken the quantities needed to apply to the results from the first curve.

The methods used for the first seven plates can be briefly described as follows:

#### 19 *Piscium*

- G 269. Red right and left reduced separately; Cornu-Hartmann correction curve assumed as zero; reduction to Sun applied.
- G 293. Red right and left reduced separately; Cornu-Hartmann curve taken as a straight line (first constants). Applied to the observed scale reading of the three standard lines, the correction from the residual curve with sign reversed, and expressed in scale divisions. Second constants, which will include the corrections from the curve, computed with these corrected scale readings. Reduction to Sun then applied.
- G 259. Red left. Same as G 293.  
Red right. Measured February 26 and March 1, 1901; shift found and two sets of measures reduced separately.  
Reductions same as before, except that the reduction to Sun was combined with the correction from the Cornu-Hartmann (straight-line) curve.
- G 357. Same as last. Same correction curve for measures right and left.
- G 264. Same as last.
- G 343. Shift found between measures of March 11 and 12, 1901, two parts reduced separately; otherwise same as last.

#### 152 *Schjellerup*

- G 275. Red right and left combined before reduction, otherwise same as last.

#### CONSTANTS OF THE PLATES

The following tables contain the constants of the plates, including the wave-lengths and mean scale readings of the standard lines, the residuals corresponding to the approximate and corrected formula, the approximate and corrected values of the constants of the formula, and the reduction to the Sun. Kayser and Runge's wave-lengths were used for the standard iron lines, and those of Hasselberg for the standard titanium lines.

On account of the special methods of reduction employed, 19 *Piscium* is given first. The stars follow in the order described on p. 19. The order in the tables of constants and in the tables of detailed measures is therefore as follows:

- 19 *Piscium*.
- 280 *Schjellerup*.
- 318 *Birmingham*.
- 74 *Schjellerup*.
- 78 *Schjellerup*.
- 132 *Schjellerup*.
- 115 *Schjellerup*.
- 152 *Schjellerup*.

## PLATE G 264. 19 PISCUM

Blue Region

WAVE-LENGTH <i>Fe</i>	RED RIGHT			RED LEFT		
	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$
t.m.	mm.			mm.		
4404.93	48.0031	-01	00	37.6904	00	+01
4447.89	45.9732	+66	+72	39.7267	+56	+62
4494.74	43.8423	+19	+28	41.8478	+18	+27
4508.38	43.2639	+43	+52	42.4344	+40	+49
4528.79	42.3876	+07	+14	43.3057	+16	+23
4549.64	41.5323	+06	+12	44.1603	+18	+24
4584.02	40.1697	-01	-01	45.5275	00	+02
4661.67	37.3202	+23	+18	48.3760	+28	+23
4705.54	35.8217	+19	+11	49.8773	+16	+08
4788.37	33.2006	+19	+13	52.4998	+11	+05
4871.90	30.7980	+22	+25	54.8975	+28	+31
4924.12	29.4009	+10	+19	56.2962	+08	+17
4957.65	28.5432	-01	+10	57.1527	00	+11
1st Constants	$\left\{ \begin{array}{l} S_0 \\ c \\ \lambda_0 \end{array} \right.$	-19.4311		105.0359		
		91886.800		-91580.450		
		3042.33		3045.07		
2d Constants	$\left\{ \begin{array}{l} S_0 \\ c \\ \lambda_0 \end{array} \right.$	-19.4291		105.0339		
		91875.058		-91568.385		
		3042.13		3044.89		
Reduction to Sun: $\lambda$ 4400				t.m.	-0.43	
					$\lambda$ 5000	
					-0.49	

## PLATE G 343. 19 PISCUM

Blue Region

WAVE-LENGTH <i>Ti</i>	RED RIGHT						RED LEFT					
	For $\lambda$ 4395 to 4639			For $\lambda$ 4640 to 4940			For $\lambda$ 4395 to 4744			For $\lambda$ 4746 to 4979		
	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$
t.m.	mm.			mm.			mm.			mm.		
4387.01	50.4255	+32	+09	50.4198	+21	+09	37.9330	+14	-04	37.9418	-02	-04
4427.27	48.3368	+36	+18	48.3302	+23	+18	40.0252	+12	+01	40.0317	00	-05
4468.66	46.2929	+03	-07	46.2903	-03	-07	42.0599	00	00	42.0681	-18	-02
4481.44	45.6950	+13	+06	45.6905	+03	+06	42.6623	+01	+04	42.6711	-18	00
4512.91	44.2482	-01	-02	44.2457	-07	-02	44.1087	-12	-03	44.1165	-28	-02
4555.66	42.3886	+03	+06	42.3837	-08	+06	45.9639	-10	+02	45.9768	-27	-05
4590.12	40.9548	-14	-09	40.9510	-23	-09	47.4009	-20	-09	47.4084	-41	-06
4639.77	39.0119	+01	+04	39.0094	-06	+04	49.3436	-04	+02	49.3540	-32	00
4682.09	37.4430	+01	00	37.4420	-01	00	50.9177	-01	00	50.9199	-24	-14
4742.98	35.3230	+08	-03	35.3191	-03	-03	53.0382	-12	-20	53.0426	-25	-01
4805.44	33.3008	+22	+04	33.2981	+14	+04	55.0519	+28	+15	55.0590	+05	-12
4856.20	31.7540	+18	-02	31.7519	+11	-02	56.6023	+12	00	56.6093	-12	-04
4900.09	30.4842	+15	-03	30.4804	+02	-03	57.8747	00	-06	57.8807	-22	-08
4981.91	28.2675	+04	00	28.2652	-05	00	60.0881	-01	+06	60.0944	-25	-01
1st Con- stants	$\left\{ \begin{array}{l} S_0 \\ c \\ \lambda_0 \end{array} \right.$	-22.5504		-22.5504		110.8605		110.8605				
		99611.386		996113.86		-99448.140		-99448.140				
		3021.70		3021.70		3023.21		3023.21				
2d Con- stants	$\left\{ \begin{array}{l} S_0 \\ c \\ \lambda_0 \end{array} \right.$	-22.5504		-22.5731		110.8586		110.8520				
		99611.386		99682.675		-99473.010		-99440.955				
		3021.70		3021.00		3022.63		3022.78				
						t.m.						
						Reduction to Sun:	$\lambda$ 4400	-0.12				
							$\lambda$ 5000	-0.13				

## PLATE G 259. 19 PISCUM

## Yellow-Green Region

WAVE-LENGTH $\lambda$	RED RIGHT						RED LEFT		
	$\lambda 5250$ to $5250$			$\lambda 5150$ to $5227$					
	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$
$\mu m.$									
5169.19	.....			.....			47.2448	+60	.....
5227.30	41.0882	00	00	41.0816	00	00	48.6097	00	00
5233.12	40.9560	-04	-10	40.9496	-03	-10	48.7458	-21	-10
5269.72	40.1457	-07	00	40.1409	+01	00	49.5553	-20	00
5328.24	38.9050	-09	-01	38.8967	-17	-01	50.7950	-15	-01
5371.70	38.0972	00	00	38.0198	00	00	51.6730	00	00
5447.13	36.5805	+36	00	36.5734	+32	00	53.1236	+15	00
5495.88	35.6819	-06	-06	35.6761	-03	-06	54.0168	+07	-06
5586.99	34.1037	-39	-06	34.0973	-39	-06	55.5918	+05	-06
5615.80	33.6317	-27	+06	33.6260	-23	+06	56.0654	+12	+06
5710.75	32.1467	00	+27	32.1404	00	+27	57.5588	00	+27
1st S	-7.9827			-7.9983			97.8653		
Constants c	106470.150			106517.970			-107251.499		
	3057.58			3057.00			3049.85		
2d	-7.9806			-8.0029			97.8716		
Constants	106462.010			106543.200			-107326.399		
	3057.04			3056.08			3048.48		
Reduction to Sun: $\lambda 5200$ -0.51									
$\lambda 5800$ -0.57									

## PLATE G 293. 19 PISCUM

## PLATE G 293. 19 PISCUM

## PLATE G 357. 19 PISCUM

## Yellow-Green Region

WAVE-LENGTH $\lambda$	RED RIGHT				RED LEFT				RED LEFT				WAVE-LENGTH $\lambda$	RED RIGHT				RED LEFT				
	Mean Scale Reading		$\Delta_1$	$\Delta_2$	Mean Scale Reading		$\Delta_1$	$\Delta_2$	Mean Scale Reading		$\Delta_1$	$\Delta_2$		Mean Scale Reading		$\Delta_1$	$\Delta_2$	Mean Scale Reading		$\Delta_1$	$\Delta_2$	
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.		mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
5169.19	11.860	00	-10	17.992	00	-10	45.1292	00	-01	5173.92	36.4755	-01	-04	48.0762	00	-04	48.0762	00	-04	48.0762	00	-04
5227.30	11.874	00	00	17.877	+20	+08	42.8347	-01	-11	5230.35	35.5897	00	00	49.5629	+01	00	49.5629	+01	00	49.5629	+01	00
5233.12	42.9853	00	-10	42.7014	+06	-10	46.1398	-06	-01	5283.63	33.9151	+23	00	50.6387	+21	00	50.6387	+21	00	50.6387	+21	00
5269.72	41.9066	00	00	41.0535	00	07	47.4674	23	-05	5336.97	32.7321	+04	-04	51.7984	-20	-04	51.7984	-20	-04	51.7984	-20	-04
5328.24	40.1199	00	00	40.544	00	-04	48.4047	00	00	5381.20	31.8359	+21	00	52.7200	+20	00	52.7200	+20	00	52.7200	+20	00
5447.13	39.1652	+57	00	46.5299	-07	00	49.1677	+22	-01	5418.98	31.0741	+14	+02	53.4797	+16	+02	53.4797	+16	+02	53.4797	+16	+02
5495.88	38.3909	00	00	47.1859	-19	-11	50.9120	05	+05	5481.65	29.8657	-01	-05	49.6965	00	-02	49.6965	00	-02	49.6965	00	-02
5586.99	36.5245	+08	+06	49.1694	-15	06	53.5195	-40	-13	5565.70	28.3122	+21	+03	56.1362	+21	+03	56.1362	+21	+03	56.1362	+21	+03
5615.80	36.6686	-38	00	49.6773	-16	00	53.5195	22	+06	5604.36	26.0664	01	+02	57.3828	04	+02	57.3828	04	+02	57.3828	04	+02
5710.75	34.1081	00	+35	51.592	00	+35	54.5913	00	+35	5739.69	25.4805	-20	-10	59.0391	-10	-10	59.0391	-10	-10	59.0391	-10	-10
1st S	-15.971			94.5758			-9.4841			97.9301	1st S	-15.8800		100.2952			100.2952			100.2952		
Constants c	112161.831			-115677.489			113758.396			-115281.415	Constants c	111461.870		-110739.850			-110739.850			-110739.850		
	3043.41			3039.76			3043.98			3043.98		3044.53		3052.09			3052.09			3052.09		
2d	-9.4820			-9.4820			-9.4820			97.9575	2d	-15.8947		100.3065			100.3065			100.3065		
Constants	113596.597			113596.597			115334.071			-115334.071	Constants c	111510.045		-110842.820			-110842.820			-110842.820		
	3043.54			3043.15			3043.15			3043.15		3044.24		3051.34			3051.34			3051.34		
Reduction to Sun: $\lambda 5200$ -0.49										Reduction to Sun: $\lambda 5200$ -0.52												
$\lambda 5800$ -0.45										$\lambda 5800$ -0.58												

## 280 SCHJELLERUP

## Blue Region

PLATE G 365				PLATE G 367			
Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
49.3729	4443.7	+60	+60	63.2423	4399.92	00	00
49.8135	4457.59	00	-02	62.3717	4427.28	-03	+06
51.4204	4512.88	-02	+05	61.4266	4457.59	-53	-35
51.5627	4518.18	+18	+25	60.7309	4481.41	-32	-10
52.5929	4555.64	-33	-20	59.8395	4512.88	-25	00
53.4724	4590.11	+20	+34	59.6911	4518.18	-31	-06
54.1599	4617.41	-28	-16	59.5639	4522.97	-14	+11
55.0952	4656.60	-06	-01	58.6853	4555.64	-20	+04
55.6826	4682.08	00	+05	57.7949	4590.11	-36	-16
57.3454	4758.30	+36	-05	57.1238	4617.41	-22	06
58.2813	4805.56	+52	+25	56.1976	4656.60	-08	-01
58.9789	4841.00	-15	-41	55.6183	4682.08	00	00
61.4564	4981.91	00	+03	54.2993	4742.94	-01	-12
.....	.....	.....	.....	53.5457	4780.18	+43	+27
.....	.....	.....	.....	52.0805	4856.18	+19	+01
.....	.....	.....	.....	49.9083	4981.91	00	00
$S_0$	94.0103				18.0710		
$c$	-64792.977				62770.074		
$\lambda_0$	2991.58				3010.32		
Reduction to Sun: $\lambda$ 4400 +0.03				t.m.			
$\lambda$ 5000 +0.04				-0.24			
				-0.28			

## 280 SCHJELLERUP

## Yellow-Green Region

PLATE G 366				PLATE G 370			
Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
40.9966	5173.92	00	+06	48.8976	5173.92	00	00
41.8908	5210.49	-25	-07	49.371	5193.14	+02	+18
43.8858	5297.21	-46	-29	49.7986	5210.49	-34	-11
44.7375	5336.96	+02	+07	50.1572	5226.70	+82	+109
45.6630	5381.20	00	-07	52.6575	5336.97	00	+02
45.9835	5396.71	-21	-30	53.5845	5381.20	+09	-04
46.2404	5409.81	+12	00	54.3470	5418.98	+27	+06
46.4255	5418.98	+02	-11	57.1059	5565.70	+11	-02
47.7924	5490.36	+43	+25	58.4564	5644.36	00	00
49.1699	5565.70	+06	-06	.....	.....	.....	.....
50.5148	5644.36	00	+02	.....	.....	.....	.....
$S_0$	93.5694				101.4441		
$c$	-111874.379				-111170.513		
$\lambda_0$	3045.93				3058.26		
Reduction to Sun: $\lambda$ 5200 -0.28				t.m.			
$\lambda$ 5800 -0.32				-0.29			
				-0.33			

## 318 BIRMINGHAM

## Blue Region

PLATE G 276				PLATE G 393			
Mean Scale Reading	Wave-Length F <sub>c</sub>	Δ <sub>1</sub>	Δ <sub>2</sub>	Mean Scale Reading	Wave-Length T <sub>i</sub>	Δ <sub>1</sub>	Δ <sub>2</sub>
mm.	t.m.			mm.	t.m.		
64.4229	4383.72	+08	+02	53.2909	4338.05	00	+03
63.2501	4404.93	00	00	54.9209	4367.81	-19	-02
62.6931	4415.29	+01	+03	56.6851	4399.92	-26	-01
59.5733	4476.19	-13	00	58.1195	4427.27	-24	+06
58.6767	4494.74	-15	00	59.6501	4457.59	-31	+02
57.0916	4528.80	-12	00	62.5149	4518.20	-29	-02
56.1596	4549.64	-06	00	64.1621	4555.66	-07	+07
54.6749	4584.02	00	-02	65.6139	4596.72	00	+03
51.5566	4661.67	+19	-02	66.7210	4617.41	-01	-05
49.9257	4705.13	-07	-27	69.1905	4682.09	+20	00
47.0665	4788.14	+28	+05	71.8860	4758.87	+36	+02
44.4345	4871.87	+26	+10	73.4022	4805.44	+60	+23
43.8522	4891.37	+13	00	74.5215	4841.00	+24	00
41.9707	4957.67	00	-03	75.8467	4885.25	+27	00
.....	.....	.....	.....	78.5343	4981.91	00	00
S <sub>a</sub>	10.1483			129.8943			
c	99367.483			-100110.616			
λ <sub>0</sub>	3051.12			3032.72			
Reduction to Sun: λ4400 +0.05				t.m. -0.24			
λ5000 +0.05				-0.27			

## 318 BIRMINGHAM

## Yellow-Green Region

PLATE G 273				PLATE G 284				PLATE G 379			
Mean Scale Reading	Wave-Length F <sub>c</sub>	Δ <sub>1</sub>	Δ <sub>2</sub>	Mean Scale Reading	Wave-Length F <sub>c</sub>	Δ <sub>1</sub>	Δ <sub>2</sub>	Mean Scale Reading	Wave-Length T <sub>i</sub>	Δ <sub>1</sub>	Δ <sub>2</sub>
mm.	t.m.			mm.	t.m.			mm.	t.m.		
57.2442	5169.16	+76	+67	55.0796	5169.16	+32	+13	52.1792	5336.97	00	00
58.6969	5227.30	00	00	56.5300	5227.30	00	-09	53.1100	5381.20	+14	+14
59.6921	5269.72	00	-08	57.5747	5269.72	-22	-06	53.8872	5418.98	-20	-20
61.0101	5328.24	-17	-05	58.9138	5328.24	-27	-11	55.2737	5490.36	00	00
61.9698	5371.70	00	-08	59.8623	5371.70	00	00	56.6576	5565.70	-05	-05
63.4698	5447.13	+04	-01	61.4332	5447.13	+18	-05	57.2308	5598.±	.....	.....
66.0718	5586.99	-05	-09	64.0932	5586.99	+06	-09	58.0153	5644.36	00	00
66.5719	5615.80	00	-01	64.6082	5615.80	00	-01	.....	.....	.....	.....
68.1374	5710.75	+26	-33	66.2106	5710.75	+11	-13	.....	.....	.....	.....
S <sub>a</sub>	98.4298			-8.8018				101.8299			
c	-109164.979			111732.492				-114566.029			
λ <sub>0</sub>	3053.70			3087.52				3029.39			
Reduction to Sun: λ5200 +0.16 λ5800 +0.17				t.m. +0.03 +0.03				t.m. 0.00 0.00			

## 74 SCHJELLERUP

## Blue Region

PLATE G 383				PLATE G 391			
Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
59.7101	4367.81	00	-12	63.7228	4338.05	00	+02
58.6411	4387.01	-05	-11	62.0096	4367.81	-10	-03
56.5137	4427.27	+15	+15	60.9454	4387.01	-13	-04
54.9766	4457.59	00	+04	58.8166	4427.27	-13	-02
53.4843	4488.98	+32	+38	57.2945	4457.59	-08	+02
52.1098	4518.20	-02	+03	55.8020	4488.98	-36	+43
50.4506	4555.66	-11	-10	54.6765	4512.88	-03	+01
49.0041	4590.12	00	-04	52.7859	4555.66	+05	+04
47.9038	4617.41	+09	00	51.3311	4590.12	00	-08
45.4380	4682.09	+15	+02	50.2342	4617.41	+13	+01
42.7401	4758.87	-22	-22	49.3627	4639.81	-35	+19
41.2337	4805.44	00	-10	47.7783	4682.09	-57	+35
39.6574	4856.20	-53	-37	45.0831	4758.91	+50	+24
36.1047	4981.91	-24	00	43.5719	4805.44	+77	+51
.....	.....	.....	.....	41.9998	4856.20	+54	+32
.....	.....	.....	.....	38.4530	4981.91	00	-06
$S_0$	-14.0069				-12.5623		
$c$	96452.828				96163.762		
$\lambda_0$	3059.39				3038.14		
		t.m.			t.m.		
Reduction to Sun :	$\lambda$ 4100	-0.27			-0.41		
	$\lambda$ 5000	-0.30			-0.47		

## 74 SCHJELLERUP

## Yellow-Green Region

PLATE G 373				PLATE G 386			
Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
49.4201	5173.92	00	+05	46.2325	5129.32	+23	-23
48.9478	5193.15	-04	+03	45.1015	5173.92	00	-07
48.5252	5210.55	-17	-09	44.2076	5210.55	-18	-06
46.8421	5283.63	+15	+25	42.5254	5283.63	+06	+20
45.6696	5336.96	-16	-06	41.3588	5336.96	-06	+05
44.7454	5381.20	-06	+02	40.4318	5381.20	-14	-06
43.9827	5418.98	00	+05	39.6717	5418.98	00	+05
42.7605	5481.64	-38	-36	38.4555	5481.64	-14	-12
41.2329	5565.70	-56	-55	38.0363	5504.10	-10	-08
40.6544	5598.52	.....	.....	36.9235	5565.70	-07	-05
39.8877	5644.36	00	+03	35.5795	5644.37	00	+04
38.3625	5739.69	+12	+21	34.5041	5710.75	-10	-03
$S_0$	-3.2961				-7641.6		
$c$	112342.502				112652.526		
$\lambda_0$	3042.96				3038.56		
		t.m.			t.m.		
Reduction to Sun :	$\lambda$ 5200	-0.11			-0.41		
	$\lambda$ 5800	-0.13			-0.46		

## 78 SCHJELLERUP

## Blue Region

PLATE G 341				PLATE G 342			
Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
61.1672	4367.81	00	+05	54.8138	4367.81	+16	+06
62.1143	4387.00	-16	-05	53.7195	4387.00	00	-02
60.8363	4411.24	-18	-01	52.4548	4411.24	-09	-04
58.5141	4457.59	-22	00	50.0992	4457.59	-29	-12
55.9369	4512.88	-22	+02	47.4950	4512.88	-23	+01
54.0798	4555.64	-04	+10	45.6095	4555.64	-19	+04
52.6517	4590.11	-03	+02	44.1637	4590.11	-18	+01
51.5655	4617.41	00	-04	43.0637	4617.41	-15	00
49.1406	4682.08	+19	-03	40.6050	4682.09	00	00
47.0254	4742.94	+36	+02	38.4597	4742.94	+12	00
43.9084	4841.00	+35	+01	36.4064	4805.44	+28	+09
42.1884	4900.10	+34	+09	35.3002	4841.00	+18	-04
39.9713	4981.91	00	-03	33.9833	4885.25	+21	+02
.....	.....	.....	.....	31.3066	4981.91	00	00
<i>S</i>	-10.3146				-20.1282		
<i>c</i>	97825.631				100724.798		
$\lambda$	3036.52				3023.61		
Reduction to Sun :		t.m.			t.m.		
	$\lambda$ 4400	-0.41			-0.42		
	$\lambda$ 5000	-0.47			-0.47		

## 78 SCHJELLERUP

## Yellow-Green Region

PLATE G 390				PLATE G 384			
Mean Scale Reading	Wave-Length <i>F<sub>c</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
48.6220	5169.16	+80	+80	48.7537	5129.32	-01	-01
47.1559	5227.30	00	+08	47.6129	5173.92	00	+08
47.0039	5233.12	-48	-22	46.7019	5210.55	-37	-24
46.1419	5269.72	-38	00	43.8175	5336.96	-15	-08
44.8091	5328.24	-46	-01	42.8835	5381.20	00	+02
43.8552	5371.70	00	+26	42.1128	5418.98	+10	+07
42.3283	5447.13	+56	+11	40.4598	5504.10	+12	+04
39.6709	5586.99	+01	-25	39.3302	5565.70	-05	-15
39.1611	5675.87	00	-24	37.9753	5644.37	+31	+22
37.5737	5710.75	+91	+78	36.4263	5739.69	-11	-17
.....	.....	.....	.....	34.2046	5890.19	00	+04
.....	.....	.....	.....	34.1190	5896.16	-16	-09
<i>S</i>	-6.1511				-5.4517		
<i>c</i>	117379.147				112414.141		
$\lambda$	3025.37				3055.48		
Reduction to Sun :		t.m.			t.m.		
	$\lambda$ 5200	-0.47			-0.35		
	$\lambda$ 5800	-0.52			-0.39		

132 SCHJELLERUP  
Blue Region

A 328				G 300				G 308			
Mean Scale Reading	Wave-Length $T_1$	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length $F_1$	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length $T_1$	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.			mm.	t.m.		
31.5024	4385.17	-02	-03	62.4163	4401.93	00	00	56.7597	4387.01	00	+03
31.9008	4399.92	00	+01	60.2114	4447.89	-48	+63	54.6542	4427.27	-14	+03
34.1584	4427.28	-07	+01	59.2437	4466.73	-17	+03	53.1443	4457.59	-29	-03
35.4942	4443.97	-13	-01	57.8957	4494.74	-22	+03	52.0070	4481.44	-27	+03
35.9139	4449.32	-12	+01	57.2672	4508.38	-05	+21	50.5589	4512.88	-32	00
36.5603	4457.59	-17	-03	56.3247	4528.79	-30	-03	48.6922	4555.66	-27	+02
38.3718	4481.41	-17	+01	55.4063	4549.64	-15	+10	47.2555	4590.11	-37	-14
39.8503	4501.43	-10	00	53.9336	4584.02	-18	+02	45.3119	4639.83	-03	+05
40.6756	4512.88	-17	+02	50.8472	4661.67	00	00	43.7368	4682.09	00	00
41.7110	4527.48	-15	+03	49.2341	4705.54	+22	+06	41.6096	4742.98	+15	00
42.9227	4544.83	-24	-08	46.3933	4788.37	-21	-04	39.5773	4805.41	+28	-01
43.449	4552.62	-15	00	43.7829	4871.90	-01	-13	38.0231	4856.20	+24	-01
43.6524	4555.64	-13	+01	43.2143	4891.67	+47	+37	36.7454	4900.09	+12	+03
44.2083	4563.94	-08	+05	42.2717	4924.12	00	-04	34.5165	4981.91	00	-03
45.9286	4590.11	-01	+06	41.3449	4957.65	00	+03	.....	.....	.....	.....
47.6681	4617.41	-03	-03	.....	.....	.....	.....	.....	.....	.....	.....
48.9299	4623.24	00	-02	.....	.....	.....	.....	.....	.....	.....	.....
48.4157	4629.47	00	-05	.....	.....	.....	.....	.....	.....	.....	.....
50.0564	4656.60	+07	-05	.....	.....	.....	.....	.....	.....	.....	.....
50.7129	4667.76	-14	-01	.....	.....	.....	.....	.....	.....	.....	.....
51.5433	4682.08	-23	+05	.....	.....	.....	.....	.....	.....	.....	.....
52.5096	4698.94	-21	00	.....	.....	.....	.....	.....	.....	.....	.....
54.9363	4742.94	-25	-02	.....	.....	.....	.....	.....	.....	.....	.....
55.8169	4759.44	-23	-06	.....	.....	.....	.....	.....	.....	.....	.....
59.9223	4841.00	+36	+07	.....	.....	.....	.....	.....	.....	.....	.....
62.0044	4885.25	+32	+08	.....	.....	.....	.....	.....	.....	.....	.....
66.2345	4981.91	00	00	.....	.....	.....	.....	.....	.....	.....	.....
67.5660	5014.40	-16	-04	.....	.....	.....	.....	.....	.....	.....	.....
$S_0$	147.4070				-10.8653				-16.6050		
$e$	-158930.815				100360.323				100308.480		
$\lambda_0$	3023.97				3035.41				3019.75		
			t.m.				t.m.				t.m.
Reduction to Sun:	$\lambda$ 4400	+0.09			-0.12				-0.38		
	$\lambda$ 5000	+0.11			-0.14				-0.43		

132 SCHJELLERUP  
Yellow-Green Region

Wave-Length $F_1$	PLATE G 209			PLATE G 301		
	Mean Scale Reading	$\Delta_1$	$\Delta_2$	Mean Scale Reading	$\Delta_1$	$\Delta_2$
t.m.				mm.		
5169.19	.....	00	+04	47.1218	+12	-03
5227.30	45.0723	-10	-04	45.6560	00	+07
5233.12	44.9302	-28	-09	45.5080	-26	-16
5269.72	44.0654	-29	00	44.6418	-23	-03
5328.24	42.7445	00	+32	43.3136	-14	00
5371.70	41.8177	-23	+07	42.3719	00	+04
5447.13	40.2555	-28	-16	40.8215	+42	+38
5586.99	37.6158	00	+06	38.1675	+03	-01
5615.80	37.1108	+04	+70	37.6577	00	+01
5710.75	35.5259			36.0667	+61	+72
$S_0$	-8.9628				-7.3702	
$e$	121504.394				115975.198	
$\lambda_0$	2978.68				3040.17	
			t.m.			t.m.
Red. $\lambda$ 5200	0.00				-0.01	
to Sun: $\lambda$ 5800	0.00				-0.01	

## 115 SCHJELLERUP

## Blue Region

PLATE G 383				PLATE G 382			
Mean Scale Reading	Wave-Length $T_1$	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length $T_1$	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
51.3959	4457.59	00	-06	55.9916	4387.00	00	+04
49.3290	4522.97	+01	+05	54.8351	4421.92	-26	-10
48.4488	4555.64	-05	+01	53.7213	4457.59	-29	-07
47.5625	4590.11	+01	+07	52.1040	4512.88	-12	+09
46.8846	4617.41	-05	-01	51.9529	4518.18	-19	+01
45.3717	4682.08	00	-04	51.8199	4522.97	-16	+03
44.9979	4698.94	+13	+06	50.9310	4555.64	+14	+24
44.0490	4742.94	+07	-07	50.0328	4590.11	-09	-12
43.7169	4759.07	+18	+01	49.3571	4677.47	00	-16
43.2898	4779.98	+10	-09	47.8300	4682.08	+41	+05
42.7865	4805.56	+30	+07	46.4976	4712.94	+51	+11
42.1030	4841.00	+08	-12	46.1608	4758.87	+37	-02
41.8180	4836.18	-01	-20	45.2229	4805.56	+67	+33
41.2918	4885.25	+15	00	44.529	4841.00	+16	-08
39.6410	4981.91	00	00	44.245	4856.18	+20	00
				42.0543	4981.91	00	+02
$S_0$	7.5171				10.3552		
$c$	63628.789				61749.228		
$\lambda_0$	3001.18				3033.93		
Reduction to Sun: $\lambda$ 4100				t.m.			
				+0.25			
$\lambda$ 5000				-0.01			
				-0.01			

## 115 SCHJELLERUP

## Yellow-Green Region

PLATE G 365				PLATE G 374			
Mean Scale Reading	Wave-Length $T_1$	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length $T_1$	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
45.5753	5173.94	00	+08	46.4304	5173.94	00	+01
45.0954	5193.15	-44	-32	45.9616	5193.15	+06	+12
44.6801	5210.55	-34	-20	45.5358	5210.55	-24	-15
41.8458	5336.96	+04	+08	42.688	5336.96	-09	+01
40.1694	5381.20	00	-12	41.7645	5381.20	00	+02
40.1694	5419.00	+31	+12	41.0031	5419.00	+10	+04
38.5433	5504.10	+28	+03	39.6318	5469.90	-05	-20
37.4348	5565.70	+23	+04	38.2585	5565.70	+21	+04
36.0934	5644.37	00	-06	36.9095	5644.37	00	-07
32.711	5866.69	-61	-45	.....	.....	.....	.....
$S_0$	-6.4285				-6.3081		
$c$	106710.332				112617.276		
$\lambda_0$	3064.28				3038.55		
Reduction to Sun: $\lambda$ 5200				t.m.			
				+0.29			
$\lambda$ 5800				+0.32			
				+0.20			
				+0.22			

## 152 SCHJELLERUP—Blue Region

PLATE G 316				PLATE G 319			
Mean Scale Reading	Wave-Length <i>F<sub>e</sub></i>	$\Delta_1$	$\Delta_2$	Scale Mean Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
58.4979	4404.93	00	00	62.2942	4387.01	00	00
53.9627	4494.74	-28	+02	60.1744	4427.27	-04	+05
53.3353	4508.38	-05	+26	58.1132	4468.66	-17	+02
52.3887	4528.79	-34	-05	57.1631	4488.86	+04	+25
51.4690	4549.64	-18	+08	56.0399	4512.88	-25	-02
49.9958	4584.02	-15	+04	54.1548	4555.66	-21	+01
46.9014	4661.67	00	00	52.7090	4590.12	-20	-02
45.2818	4705.54	+12	00	50.7415	4639.77	+02	+09
42.4443	4788.37	+33	+01	49.1495	4682.09	00	-02
39.8347	4871.90	+30	00	47.0010	4742.98	+14	-01
38.3177	4924.12	+18	+01	44.9514	4805.44	+35	+14
37.3848	4957.65	00	-02	43.3770	4856.20	+17	-04
.....	.....	.....	.....	42.0906	4900.09	+23	+06
.....	.....	.....	.....	39.8372	4981.91	00	-02
$S_0$	-14.7723				-11.8813		
$c$	100044.671				101624.571		
$\lambda^0$	3039.51				3016.95		
Reduction to Sun:	$\lambda$ 4400	t.m.			t.m.		
	$\lambda$ 5000	-0.13			-0.15		
		-0.15			-0.17		

## 152 SCHJELLERUP—Blue Region

PLATE A 313				PLATE A 319			
Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$	Mean Scale Reading	Wave-Length <i>T<sub>i</sub></i>	$\Delta_1$	$\Delta_2$
mm.	t.m.			mm.	t.m.		
37.5957	4417.88	+06	+02	34.1864	4400.74	-82	00
38.3621	4427.27	+01	00	36.4392	4427.28	-74	+02
40.7605	4457.59	-11	-04	37.7721	4443.97	-72	00
41.6063	4468.65	-09	00	38.8382	4457.59	-72	-04
42.5699	4481.41	-13	-02	40.6509	4482.84	-76	-13
44.0444	4501.43	-13	-01	42.1245	4501.43	-58	-03
44.8692	4512.88	-12	00	43.3250	4518.20	-45	+03
45.9009	4527.48	-09	+03	43.9798	4527.48	-03	+03
47.1070	4544.83	-13	-02	45.1841	4544.83	-36	+01
47.8423	4555.66	-10	00	45.9218	4555.66	-34	00
48.4016	4563.94	-14	-04	46.4787	4563.94	-30	00
48.9422	4572.15	-05	+03	48.2013	4590.11	-23	-03
50.1159	4590.11	-04	+01	49.9321	4617.41	-08	-04
51.8489	4617.41	00	-01	50.2910	4623.24	00	00
52.2177	4623.24	00	-03	51.3057	4639.75	+03	-05
53.2231	4639.85	+13	+06	52.9721	4667.76	+21	00
54.2324	4656.60	+10	00	53.8034	4682.08	+28	+01
54.8889	4667.76	+15	+03	57.1887	4742.94	+45	+01
55.7234	4682.08	+14	00	58.0670	4759.44	+46	-01
59.1079	4742.94	+20	-01	60.4270	4805.44	+53	+01
59.9186	4758.30 du	+33	+11	62.1738	4841.00	+48	-03
59.9866	4759.44	+18	-04	64.2508	4885.25	+48	+04
61.0582	4780.	.....	.....	68.4778	4981.91	00	-01
62.3381	4805.25	+18	-05	.....	.....	.....	.....
64.0888	4841.00	+21	-01	.....	.....	.....	.....
64.8097	4856.18	+27	+05	.....	.....	.....	.....
66.1663	4885.25	+18	00	.....	.....	.....	.....
66.8361	4900.08	+27	+11	.....	.....	.....	.....
67.4510	4913.76	+22	+08	.....	.....	.....	.....
70.3827	4981.91	00	00	.....	.....	.....	.....
$S_0$	151.4543				148.7024		
$c$	-158811.978				-155701.597		
$\lambda_0$	3023.00				3041.09		
Reduction to Sun:	$\lambda$ 4400	t.m.			t.m.		
	$\lambda$ 5000	-0.13			+0.08		
		-0.15			+0.10		

## 152 SCHJELLERUP

## Yellow-Green Region

WAVELENGTH <i>Fe</i>	PLATE G 275				PLATE G 294				PLATE G 302			
	Mean Scale Reading	$\Delta_1$	$\Delta_2$		Mean Scale Reading	$\Delta_1$	$\Delta_2$		Mean Scale Reading	$\Delta_1$	$\Delta_2$	
t.m.	mm.				mm.				mm.			
5169.19	46.8204	+63	+52		.....		.....		50.7350	+70	+53	
5227.30	45.3563	-01	+01		45.4829	(00)	+06		49.2714	(00)	(00)	
5233.12	45.2147	04	00		.....		.....		49.1235	-30	-27	
5269.72	44.3428	-19	00		44.4743	-22	-02		48.2586	-20	(00)	
5328.24	43.0113	-25	-03		43.1478	-37	-12		46.9297	-19	(00)	
5371.70	42.0721	-01	+10		42.2151	(00)	+07		45.9897	(00)	+07	
5447.13	40.5139	00	+01		40.6580	-23	-20		44.4318	+03	-05	
5586.90	37.8635	-36	-11		38.0212	-24	+11		41.7862	+06	(00)	
5615.80	37.3562	-28	+01		37.5066	-63	-22		41.2756	(00)	-01	
5710.75	35.7619	-01	+36		37.9205	(00)	-51		39.6857	+73	+84	
1st $\lambda$ S	-7.4490				-7.7545				-3.9509			
Constants $\lambda$	114977.007				117551.985				116954.193			
	3049.92				3019.23				3029.83			
2d $\lambda$ S	-7.4458											
Constants $\lambda$	114945.901											
	3050.55											
Red. $\lambda$ 5200	t.m. -0.29				t.m. +0.22				t.m. 0.00			
to Sun: $\lambda$ 5800	+0.33				+0.26				0.00			

## DETAILED MEASURES AND REDUCTIONS

The following tables contain the detailed measures and reductions, made by Mr. Parkhurst, of the spectra of eight fourth-type stars. The intensities of the lines were estimated on a scale of 10, but on account of variations in exposure time, etc., these numbers should be taken as only roughly approximate. The character of the line, whether dark (D) or bright (B), wide (w) or nebulous (n), is indicated in the second column. "Max." indicates the point of maximum intensity of a bright space. In the case of 19 *Piscium*, the first star measured, the red-right and red-left measures are given separately; for other stars the combined measures are given. The other details of the tables will be readily understood after reference to pp. 17-20.

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 264

 1898, December 31, G.M.T. 12<sup>h</sup>5. Hour angle, W 1<sup>h</sup>6. Star fair; comparison fair.

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Wave-Length Reduced to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	μm.	mm.	μm.	μm.		μm.
1	D	49.4583	4375.83	.....	.....	75.83	+4	4375.87
10	w D	49.0257	4384.26	36.6497	4383.92	84.09	+2	4384.11
2-3	n D	48.7164	4390.35	36.9718	4380.26	90.31	+5	4390.36
5	wn D	48.4777	4385.09	37.2100	4394.98	95.04	+1	4385.05
1	n D	48.1790	4401.07	37.5230	4401.24	01.16	0	4401.16
3	B	48.1086	4402.46	37.5892	4402.56	02.51	-1	4402.50
10	w D	47.9844	4404.99	37.7133	4405.07	05.03	-1	4405.02
2	D	47.7966	4408.80	37.8839	4408.53	08.67	-1	4408.66
4-5	nn D	47.4752	4415.40	38.2109	4415.20	15.30	-2	4415.28
1	D	47.0649	4423.21	38.6028	4423.29	23.25	-3	4423.22
1	B	46.9227	4426.80	38.7784	4426.94	26.87	-3	4426.84
2	n D	46.8768	4427.76	38.8158	4427.72	27.74	-4	4427.70
6-7	n D	46.7556	4430.29	38.9412	4430.34	30.32	-4	4430.28
1	wn D	46.4910	4435.86	39.1935	4435.65	35.76	-5	4435.71
1-2	n D	46.3786	4438.24	39.3215	4438.36	38.30	-5	4438.25
2	n B	45.9572	4447.24	39.7303	4447.08	47.32	-6	4447.26
4-5	n D	45.8900	4448.69	39.8206	4449.03	48.86	-6	4448.90
1	n D	45.8238	4450.11	39.8816	4450.30	50.21	-6	4450.15
3-4	n D	45.5807	4455.38	40.1234	4455.58	55.48	-7	4455.41
1	n D	45.2650	4462.28	40.4334	4462.35	62.32	-8	4462.24
1	wn B	45.1861	4464.01	40.5143	4464.12	64.07	-8	4463.99
1	n D	45.1212	4465.44	40.5767	4465.50	65.47	-8	4465.39
1-2	n D	44.9537	4469.14	40.7469	4469.26	69.20	-8	4469.12
2	D	44.4648	4480.06	41.2307	4480.06	80.06	-9	4479.97
3	B	44.3755	4482.06	41.3301	4482.30	82.18	-9	4482.09
3	B	44.2939	4483.92	41.3986	4483.85	83.89	-9	4483.80
2	B	44.1962	4486.13	41.5013	4486.17	86.15	-9	4486.00
1-2	B	44.1344	4487.54	41.5647	4487.84	87.69	-9	4487.60
2-3	D	44.0846	4488.67	41.6159	4488.78	88.73	-9	4488.64
3	D	44.0336	4489.83	41.6631	4489.85	89.84	-9	4489.75
6	D	43.7130	4497.18	41.9863	4497.26	97.22	-9	4497.13
2-3	n D	43.5080	4501.90	42.1834	4501.81	01.86	-9	4501.77
6	n D	43.2936	4506.91	42.3992	4506.83	06.87	-9	4506.78
1	wn D	43.1708	4509.78	42.5209	4509.68	09.73	-9	4509.64
2	n B	43.0210	4513.31	42.6451	4512.60	12.96	-9	4512.87
4	D	42.8573	4517.17	42.8380	4517.15	17.16	-8	4517.08
1	D	42.8054	4518.40	42.8875	4518.32	18.30	-8	4518.28
3-4	B	42.7142	4520.57	42.9886	4520.72	20.65	-8	4520.57
5	D	42.6637	4521.77	43.0223	4521.76	21.77	-8	4521.69
6	w D	42.6061	4523.14	43.0869	4523.00	23.07	-7	4523.00
2-3	n D	42.4210	4527.58	43.2698	4527.44	27.51	-7	4527.44
3-4	D	42.2569	4531.53	43.4331	4531.37	31.45	-7	4531.38
3	B	42.0727	4535.99	43.6198	4535.89	35.94	-7	4535.87
3	B	42.0109	4537.49	43.6835	4537.44	37.47	-7	4537.40
3	D	41.9467	4539.06	43.7505	4539.07	39.07	-7	4539.00
1	D	41.8845	4540.58	43.8122	4540.58	40.58	-7	4540.51
1	B	41.7920	4542.84	.....	.....	42.84	-6	4542.78
2	D	41.7382	4544.16	43.9612	4544.29	44.19	-6	4544.13
3	B	41.5867	4547.89	44.1094	4547.87	47.88	-6	4547.82
5	D	41.5253	4549.41	44.1622	4549.17	49.29	-6	4549.23
10	w D	41.3521	4553.70	44.3387	4553.55	53.63	-6	4553.57
Limits	.....	.....	.....	44.2780	4552.04	52.04	-6	4551.98
3	D	41.0807	4560.40	44.3920	4554.87	54.87	-6	4554.81
3	n B	41.0220	4561.95	44.6065	4560.31	60.36	-5	4560.31
2-3	D	40.9601	4563.51	44.6776	4562.02	61.99	-5	4561.94
1	D	40.8795	4565.55	44.7490	4563.82	63.67	-5	4563.62
2	w D	40.8343	4571.76	44.8262	4565.76	65.66	-4	4565.62
2	n B	40.1983	4583.78	45.0599	4571.69	71.73	-4	4571.69
1	D	40.1297	4584.72	45.5262	4583.65	83.72	-2	4583.70
1	B	40.1032	4585.41	45.5658	4584.68	84.70	-2	4584.68
2	n D	40.0609	4586.51	45.5976	4585.50	85.46	-2	4585.44
1	D	39.8808	4590.96	45.6273	4586.27	86.39	-2	4586.37
2-3	n D	39.7594	4594.37	45.8109	4591.05	91.01	-2	4590.99
2	B	39.7022	4595.88	45.9398	4594.42	94.41	-2	4594.39
1	D	39.5104	4600.93	45.9924	4595.81	95.85	-2	4595.83
				46.1851	4600.88	00.91	-1	4600.90

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 264 - Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Wave-Length Reduced to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	t.m.	mm.	t.m.	t.m.		t.m.
10	w D	39.2826	4606.98	46.4155	4607.00	06.99	0	4606.99
2-3	n B	39.2156	4608.77	46.4797	4608.71	08.74	0	4608.74
1-2	B	39.0789	4612.43	46.6124	4612.26	12.35	0	4612.35
1	n D	39.0230	4613.93	46.6604	4613.55	13.74	0	4613.74
3	B	38.9832	4615.00	46.7142	4615.00	15.00	+1	4615.01
2	D	38.9309	4616.41	46.7644	4616.35	16.38	+1	4616.39
6	B	38.8783	4617.83	46.8188	4617.82	17.83	+1	4617.84
4	D	38.8059	4619.79	46.8866	4619.65	19.72	+1	4619.73
3	B	38.7468	4621.39	46.9497	4621.31	21.35	+2	4621.37
1	n D	38.6947	4622.81	46.9974	4622.66	22.74	+2	4622.76
4-5	n D	38.4561	4629.32	47.2306	4629.19	29.26	+2	4629.28
3	B	38.3865	4631.23	47.3098	4631.20	31.22	+3	4631.25
1	D	38.2639	4634.61	47.4331	4634.60	34.61	+3	4634.64
2	D	38.1573	4637.56	47.5330	4637.36	37.46	+3	4637.49
3	B	38.1179	4638.65	47.5759	4638.55	38.60	+3	4638.63
5-6	D	38.0556	4640.38	47.6452	4640.47	40.43	+4	4640.47
3	B	38.0055	4641.78	47.6880	4641.66	41.72	+4	4641.76
	w D	37.8532	4646.03	47.8299	4645.62	45.82	+4	4645.86
2-3	B	37.6106	4652.85	48.0828	4652.73	52.79	+4	4652.83
1	D	37.5764	4653.82	48.1234	4653.88	53.85	+4	4653.89
1	D	37.1837	4656.44	48.2069	4656.24	56.34	+5	4656.39
1-2	w B	37.3245	4660.97	48.3673	4660.80	60.89	+5	4660.94
2	D	37.2123	4664.18	48.4810	4664.05	64.12	+5	4664.17
1	n B	37.1721	4665.33	48.5299	4665.45	65.39	+5	4665.44
3	w D	37.0754	4668.11	48.6189	4668.01	68.06	+5	4668.11
4	D	36.8324	4675.13	48.8631	4675.07	75.10	+6	4675.16
1	D	36.5878	4682.26	.....	.....	82.26	+6	4682.32
1	n D	36.3793	4688.39	.....	.....	88.39	+7	4688.46
1	n D	36.2891	4691.05	49.4104	4691.11	91.08	+7	4691.15
1	n D	.....	.....	49.5178	4694.29	94.29	+7	4694.36
3-4	n D	36.1039	4696.55	49.5915	4696.48	96.52	+7	4696.59
6	w D	35.5652	4714.58	50.1909	4714.53	14.56	+8	4714.64
1-2	n D	35.2390	4722.82	50.4498	4722.45	22.64	+8	4722.72
10	w D	34.8071	4736.11	50.8826	4735.86	35.99	+8	4736.07
Head	.....	34.7613	4737.54	50.9412	4737.69	37.62	+8	4737.70
7-8	B	34.7296	4738.53	50.9701	4738.60	38.57	+8	4738.65
4-5	n D	34.5568	4743.96	51.1416	4743.99	43.98	+8	4744.06
7	B	34.4729	4746.61	.....	.....	46.61	+8	4746.69
1	n D	34.3734	4749.77	51.3089	4749.60	49.69	+8	4749.77
1-2	n D	34.0980	4758.55	51.5904	4758.26	58.41	+8	4758.49
1	D	33.8663	4766.01	51.8205	4765.67	65.84	+7	4765.91
1	D	33.6839	4772.61	52.0336	4772.58	72.60	+7	4772.67
1	n D	33.3151	4784.03	52.3886	4784.24	84.14	+6	4784.20
1	n D	33.1489	4789.53	52.5391	4789.22	89.38	+6	4789.44
1	n D	32.3595	4816.17	53.3197	4815.55	15.86	+4	4815.90
1-2	n D	32.1309	4824.19	53.5543	4823.62	23.91	+3	4823.94
1	n D	32.0206	4827.86	53.6702	4827.64	27.75	+3	4827.78
1	n D	31.8764	4832.87	53.8143	4832.65	32.76	+2	4832.78
1	n D	31.2302	4855.50	54.4570	4855.37	55.44	0	4855.44
1	n D	30.8755	4868.50	54.8195	4868.44	68.47	-2	4868.45
1	n D	30.5171	4881.67	55.1792	4881.60	81.64	-4	4881.60
End	.....	27.5040	4999.7	.....	.....	99.7	-10	4999.6

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 343

1899, October 4, G.M.T. 15<sup>h</sup>5. Hour angle, E 1<sup>h</sup>3. Star good; comparison excellent.

8	w D	39.0071	4394.56	38.3322	4394.17	94.37	+18	4394.55
1	D	49.8545	4397.46	38.1965	4397.29	97.38	+18	4397.56
3	D	49.6369	4400.40	38.6522	4400.25	00.33	+18	4400.51
4	D	49.4705	4404.79	38.8807	4404.62	04.71	+17	4404.88
4	D	49.2871	4408.31	39.0633	4407.95	08.13	+17	4408.30
1	D	49.0943	4412.11	39.2609	4411.96	12.04	+16	4412.20
2	w D	48.9511	4414.84	39.4076	4414.82	14.83	+16	4414.99
2-3	w D	48.9088	4420.38	39.6904	4420.35	20.37	+14	4420.51

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 343--Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Wave-Length Reduced to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	t.m.	mm.	t.m.	t.m.		t.m.
1-2	D	48.5498	4422.70	39.8116	4422.73	22.72	+13	4422.85
1-2	D	48.3316	4427.01	40.0362	4427.17	27.09	+12	4427.21
1-2	nD	48.1800	4430.03	40.1655	4429.74	29.89	+12	4430.01
3	nD	47.9267	4435.09	40.4406	4435.24	35.17	+10	4435.27
1	nD	47.7822	4437.99	40.5721	4437.68	37.84	+10	4437.94
2	B	47.7447	4438.75	40.6101	4438.65	38.70	+10	4438.80
2-3	nD	47.4727	4444.25	40.8899	4444.31	44.28	+8	4444.36
1	nD	47.3391	4446.97	41.0111	4446.78	46.88	+8	4446.96
2	nB	47.2673	4448.44	41.0901	4448.39	48.42	+7	4448.49
5	nD	47.2070	4449.67	41.1482	4449.58	49.63	+7	4449.70
1	D	47.0381	4453.13	41.3196	4453.09	53.11	+6	4453.17
3	nD	46.9446	4455.06	41.4083	4454.92	54.99	+6	4455.05
2	nD	46.8047	4462.11	41.7445	4461.89	62.00	+4	4462.04
3	wB	46.5158	4463.96	41.8452	4463.99	63.98	+4	4464.02
1	D	46.4508	4465.19	41.8949	4465.01	65.10	+3	4465.13
1-2	D	46.2890	4468.71	42.0685	4468.47	68.59	+3	4468.62
1	D	46.0997	4471.70	42.2541	4472.58	72.14	+2	4472.16
1-2	nD	45.9673	4475.51	42.3834	4475.32	75.42	+1	4475.43
1-2	nD	45.7601	4479.91	42.6037	4480.01	79.96	0	4479.96
3	nD	45.6485	4482.30	42.7043	4482.16	82.23	0	4482.23
2	nB	45.5985	4483.37	42.7624	4483.40	83.39	-1	4483.38
1-2	nD	45.4012	4487.62	42.9453	4487.34	87.48	-1	4487.47
2-3	D	45.3018	4489.76	43.0516	4489.63	89.70	-2	4489.68
3	nD	44.9705	4496.97	43.3809	4496.79	96.88	-3	4496.85
5	nD	44.7524	4501.75	43.6090	4501.79	101.77	-5	4501.72
6-7	D	44.5174	4506.93	43.8266	4506.59	106.76	-6	4506.70
1	D	44.3840	4509.89	.....	.....	109.89	-6	4509.83
..	wnD	44.2512	4512.85	44.0002	4512.45	12.65	-7	4512.58
3	D	44.0040	4518.39	44.3443	4518.14	18.27	-7	4518.20
3	D	43.7945	4523.12	44.5553	4522.90	23.01	-8	4522.93
4	nnD	.....	.....	44.7429	4527.16	27.16	-9	4527.07
2	D	43.4324	4531.35	.....	.....	31.35	-9	4531.26
9	D	43.2400	4535.80	45.0941	4535.19	35.50	-10	4535.40
3	nB	43.1721	4537.34	45.1821	4537.22	37.28	-10	4537.18
2	B	43.0953	4539.11	45.2577	4538.97	39.04	-10	4538.97
1	D	43.0385	4540.42	45.3146	4540.29	40.36	-10	4540.26
2	D	42.8291	4545.29	45.5259	4545.19	45.24	-10	4545.14
5	wnD	42.6501	4549.47	45.6961	4549.17	49.32	-11	4549.21
3	wD	42.4800	4553.50	45.8860	4553.62	53.56	-11	4553.45
..	nnD	42.1870	4560.40	46.1819	4560.63	60.52	-12	4560.40
2-3	D	42.0670	4563.30	46.2803	4562.98	63.14	-12	4563.02
1-2	nD	41.9547	4565.94	46.4000	4565.84	65.89	-12	4565.77
9	wD	41.7074	4571.88	46.6357	4571.50	71.69	-12	4571.57
3	nD	41.5659	4575.30	46.7910	4575.25	75.28	-12	4575.16
3-4	nD	41.4591	4577.90	46.8740	4577.26	77.60	-12	4577.48
1	D	41.3520	4580.51	47.0021	4580.39	80.45	-12	4580.33
1	D	41.2903	4582.01	47.0640	4581.90	81.96	-12	4581.84
1-2	nD	41.1819	4584.67	47.1639	4584.35	84.51	-12	4584.39
2	nD	41.1100	4586.43	47.2458	4586.36	86.40	-12	4586.28
1	nD	40.9181	4591.16	47.4355	4591.03	91.10	-12	4590.98
1	nD	40.7915	4594.30	47.5709	4594.39	94.35	-12	4594.23
1	nD	40.6562	4597.66	47.6937	4597.44	97.55	-12	4597.43
2	nD	40.5229	4600.99	47.8234	4600.68	100.84	-12	4600.72
8	wnD	40.2880	4606.90	48.0610	4606.65	106.78	-12	4606.66
1	nD	40.1482	4610.43	48.1843	4609.77	100.10	-12	4609.98
1-2	nnD	40.0085	4613.98	48.3444	4613.84	13.91	-12	4613.79
3	B	39.9655	4615.08	48.3848	4614.87	14.98	-12	4614.86
3	D	39.9165	4616.33	48.4351	4616.15	16.24	-11	4616.13
6	B	39.8578	4617.83	48.4987	4617.77	17.80	-11	4617.69
5-6	D	39.7825	4619.76	48.5691	4619.58	19.67	-11	4619.56
4-5	B	39.7178	4621.42	48.6366	4621.31	21.37	-11	4621.26
2	nD	39.6553	4623.02	48.6937	4622.78	22.90	-11	4622.79
5	B	39.4078	4629.42	48.9408	4629.16	29.29	-11	4629.18
5	B	39.3374	4631.25	49.0095	4630.95	31.10	-11	4630.99
3	B	39.0427	4638.95	49.3118	4638.85	38.90	-10	4638.80
6	D	38.9875	4640.26	49.3564	4640.02	40.14	-10	4640.04
4	B	.....	.....	49.4215	4641.76	41.76	-10	4641.66
1	D	38.4620	4654.22	.....	.....	54.22	-9	4654.13

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 343—Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-length Reduced to Sun	Mean Scale Reading	Wave-length Reduced to Sun	Uncorrected	Cor. from Curve	Corrected
		mm.	t.m.	mm.	t.m.	t.m.		t.m.
1	D	.....	.....	49.9950	4656.90	56.90	— 9	4656.81
10	D	35.5381	4736.38	.....	.....	36.38	0	4736.38
Head		35.4988	4737.54	.....	.....	37.54	0	4737.54
8	B	35.4654	4738.53	52.8867	4738.51	38.52	+ 1	4738.53
1	D	35.4245	4739.74	52.9286	4739.76	39.75	+ 1	4739.76
10	B	35.2837	4743.92	53.0573	4743.58	43.75	+ 1	4743.76
6	B	35.2043	4746.29	53.1533	4746.23	46.26	+ 2	4746.28
2 3	B	35.1009	4749.38	53.2585	4749.38	49.38	+ 2	4749.40
1	D	34.9146	4754.98	53.4435	4754.94	54.96	+ 2	4754.98
1	B	34.8816	4755.98	53.4860	4756.23	56.11	+ 3	4756.14
2	D	34.8534	4756.83	53.5053	4756.81	56.82	+ 3	4756.85
4 5	B	34.8067	4758.24	53.5524	4758.24	58.24	+ 3	4758.27
1	D	34.5459	4766.18	53.8148	4766.22	66.20	+ 4	4766.24
2	nn D	34.3475	4772.26	54.0091	4772.18	72.22	+ 4	4772.26
3	nn D	33.9685	4784.00	54.3919	4784.04	84.02	+ 5	4784.07
2	nn D	33.7998	4789.28	54.5603	4789.31	89.30	+ 6	4789.36
2 3	nn D	32.9754	4815.52	55.3857	4815.60	15.56	+ 7	4815.63
1 2	nn D	32.6015	4827.68	55.7579	4827.71	27.70	+ 7	4827.73
2	nn D	32.4702	4831.99	55.8949	4832.21	32.10	+ 7	4832.17
1	nn D	32.3447	4836.13	56.0150	4836.17	36.15	+ 6	4836.21
1	nn D	32.2511	4839.22	56.1065	4839.20	39.21	+ 6	4839.27
1	D	.....	.....	56.2309	4843.34	43.34	+ 6	4843.40
2	nn D	.....	.....	56.5819	4855.11	55.11	+ 6	4855.17
1	nn D	.....	.....	56.7058	4859.31	59.31	+ 6	4859.37
3 4	nn D	30.9979	4881.76	57.3555	4881.61	81.69	+ 2	4881.71
2	nn D	30.4566	4900.75	57.8980	4900.66	00.71	+ 1	4900.72
1	nn D	.....	.....	58.4450	4920.25	20.25	— 2	4920.23

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 259

1898, December 29, G.M.T. 11<sup>h</sup> 6. Hour angle, W 0<sup>h</sup> 6. Star fair; comparison good.

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave-length Reduced to Sun	Uncorrected	Cor. from Curve
		mm.	t.m.	mm.	t.m.	t.m.		t.m.
1-2	nn B	42.3613	5170.28	47.3639	— 41	70.50	70.39	+ 15
10	wn D	.....	.....	47.3712	— 41	73.33	73.33	+ 15
1	B	41.9086	5190.72	47.7853	— 41	90.90	90.81	+ 13
4	D	41.8593	5192.83	47.8180	— 41	92.30	92.57	+ 12
2	nn B	41.7703	5196.65	47.9262	— 41	96.94	96.80	+ 12
1	B	41.6084	5203.64	48.0819	— 41	03.66	03.66	+ 10
3 4	nn B	41.3675	5214.12	48.3318	— 41	14.54	14.33	+ 7
1	nn D	41.3137	5216.47	48.3753	— 41	16.44	16.46	+ 7
3 4	nn B	41.2667	5218.53	48.4328	— 41	18.96	18.75	+ 7
10	nn B	41.0846	5226.55	48.5035	— 42	26.03	26.20	+ 5
1	B	41.0258	5229.16	48.6722	— 42	29.52	29.34	+ 4
2	B	40.9115	5234.22	48.7755	— 42	34.11	34.17	+ 2
3 4	B	40.8582	5236.61	48.8388	— 42	36.93	36.72	+ 1
1	B	40.6931	5245.22	49.0252	— 42	45.28	45.25	— 2
5	B	40.6226	5247.18	49.0744	— 42	47.50	47.34	— 2
1 2	B	40.5796	5249.16	49.1177	— 42	49.45	49.31	— 3
1	B	40.5278	5251.46	49.1635	— 42	51.52	51.49	— 3
3	nn D	40.4412	5255.38	49.2133	— 42	56.05	55.72	— 5
2	nn B	39.9164	5270.25	49.5781	— 42	70.44	70.35	— 8
1 2	nn D	39.8752	5279.38	49.7770	— 42	79.63	79.51	— 8
4	nn D	39.5267	5283.71	49.8722	— 42	84.05	83.88	— 9
3	B	39.4967	5297.98	50.1716	— 42	98.06	98.04	— 10
2	B	39.3734	5302.76	50.2715	— 42	02.73	02.79	— 10
1	B	39.3114	5309.45	50.3224	— 42	05.23	05.09	— 9
2	B	39.2914	5313.60	50.4869	— 42	13.16	13.08	— 9
1	D	39.1691	5314.69	50.5244	— 42	14.86	14.78	— 9

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 259 - Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT			MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave-Length Red. to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	t.m.	mm.		t.m.	t.m.		t.m.
4	nn B	39.0968	5318.16	50.5956	-42	18.26	18.21	-9	5318.12
1	B	39.0021	5322.72	50.6999	-43	23.28	23.00	-8	5322.92
10	w D	38.8775	5329.05	50.8212	-43	29.14	29.10	-7	5329.03
5-6	wn B	38.6757	5338.88	51.0327	-43	39.44	39.16	-5	5339.11
1	D	38.6294	5341.14	51.0697	-43	41.26	41.20	-5	5341.15
2	wn D	38.4432	5350.30	51.2497	-43	50.11	50.21	-2	5350.19
2	n B	38.3991	5352.46	51.3054	-43	52.86	52.66	-2	5352.64
8	wn D	38.0117	5371.82	51.6930	-43	72.21	72.02	+4	5372.06
6	B	37.9536	5374.75	51.7509	-43	75.13	74.94	+4	5374.98
1	n D	37.9101	5376.94	51.7913	-43	77.17	77.06	+4	5377.10
2-3	n D	37.5143	5397.13	52.1880	-43	97.39	97.26	+17	5397.43
2-3	n B	37.3952	5403.27	52.3111	-43	103.74	103.51	+19	5403.70
0-1	n D	37.3455	5405.84	52.3572	-43	106.13	105.99	+20	5406.19
2	n B	37.3077	5407.80	52.3975	-43	108.21	108.01	+22	5408.23
2-3	n D	37.2680	5409.86	52.4355	-43	110.19	110.03	+22	5410.25
2-3	n B	37.2237	5412.17	52.4764	-43	112.32	112.25	+23	5412.47
7-8	B	37.1286	5417.13	52.5694	-43	117.17	117.15	+23	5417.38
2-3	n D	37.0772	5419.83	52.6253	-43	120.10	119.97	+24	5420.21
4	B	37.0163	5423.03	52.6768	-43	122.80	122.92	+24	5423.16
3	n B	36.9261	5427.78	52.7762	-44	128.02	127.90	+25	5428.15
2	n D	36.8838	5430.01	52.8179	-44	130.23	130.12	+25	5430.37
2	B	36.8507	5431.77	52.8541	-44	132.14	131.96	+25	5432.21
5-6	B	36.5954	5445.37	53.0982	-44	145.14	145.26	+25	5445.51
4	n D	36.5472	5447.95	53.1541	-44	148.14	148.05	+25	5448.30
4-5	n B	36.4986	5450.56	53.2079	-44	151.03	150.80	+25	5451.05
1	n B	36.4389	5453.73	53.2661	-44	154.16	153.95	+24	5454.19
2-3	n D	36.3832	5456.79	53.3184	-44	156.99	156.89	+24	5457.13
2	B	36.3477	5458.71	53.3590	-44	159.19	158.95	+24	5459.19
2	B	36.2779	5462.50	53.4243	-44	162.73	162.62	+22	5462.84
2	B	36.2277	5465.23	53.4687	-44	165.14	165.19	+22	5465.41
3	n B	36.1098	5471.67	53.5926	-44	171.91	171.79	+20	5471.99
4-5	B	35.9516	5480.37	53.7442	-44	180.23	180.30	+20	5480.50
2	D	35.9179	5482.23	53.7857	-44	182.52	182.38	+14	5482.52
2-3	B	35.6763	5495.65	54.0230	-44	195.70	195.68	+9	5495.77
2-3	D	35.6359	5497.91	54.0625	-44	197.91	197.91	+7	5497.98
1	nn D	35.5692	5501.64	54.1385	-44	202.16	201.90	+6	5501.96
1	D	35.4805	5506.63	54.2208	-44	206.79	206.71	+5	5506.76
2	n B	35.4377	5509.05	54.2629	-44	209.16	209.11	+4	5509.15
1-2	B	35.4032	5511.00	54.2908	-44	210.74	210.87	+3	5510.90
1	D	35.0960	5528.50	54.6018	-45	228.43	228.47	-2	5528.45
2	n D	34.8999	5539.80	54.8020	-45	239.96	239.88	-2	5539.86
1	n D	34.7605	5547.90	54.9421	-45	248.09	248.00	-5	5547.95
1	D	34.5117	5562.48	55.1884	-45	262.52	262.50	-8	5562.42
3	B	34.4790	5564.40	55.2197	-45	264.36	264.28	-8	5564.30
1	B	34.4454	5566.40	55.2536	-45	266.36	266.38	-9	5566.29
8	B	34.1990	5581.05	55.4956	-45	280.75	280.90	-10	5580.80
3	w D	34.1483	5584.09	55.5469	-45	283.81	283.95	-11	5583.84
3	B	34.1001	5586.99	55.5770	-45	286.82	286.91	-11	5586.80
5	B	33.9318	5597.15	55.7733	-45	297.45	297.30	-15	5597.15
1	D	33.7340	5609.19	55.9694	-45	309.38	309.29	-16	5609.13
1-2	B	33.6017	5617.31	56.0656	-45	317.12	317.22	-18	5617.04
2	n D	33.4768	5625.03	56.2165	-46	324.29	324.40	-20	5624.60
8	D	33.3240	5634.53	56.3731	-46	329.94	329.94	-21	5634.21
Head	....	33.2937	5636.42	56.3994	-46	335.93	336.18	-22	5635.96
4	B	32.9891	5655.59	56.7067	-46	355.25	355.42	-24	5655.18
1	D	32.7514	5670.76	56.9532	-46	371.10	370.93	-27	5670.67
4	B	32.7059	5673.08	56.9978	-46	373.83	373.76	-27	5673.49
2	B	32.5241	5685.43	57.1765	-46	385.35	385.39	-29	5685.10
1	D	32.4993	5687.04	57.2066	-46	387.30	387.17	-29	5686.88
5	B	32.2264	5704.89	57.4762	-46	404.92	404.91	-30	5704.61
2	n B	32.1462	5710.18	57.5524	-46	409.94	410.06	-32	5709.74
6	B	32.0245	5718.25	...	...	...	18.25	-33	5717.92
8	n B	...	...	57.7693	-47	24.33	24.33	-33	5724.00

19 PISCUM = 273 SCHJELLERUP. PLATE G 269

1899, January 6, G.M.T. 12<sup>h</sup> 3. Hour angle, W 1<sup>h</sup> 9. Star excellent; comparison fair.

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave-Length Red. to Sun	Uncorrected	Cor. by Curve
		mm.	m.	mm.	t.m.	t.m.	t.m.	t.m.
Head		45.4603	5167.99	40.2512	-49	68.46	68.23	+25
3	B	45.3811	5171.09	40.3168	-49	71.03	71.06	+25
7	D	45.3160	5173.64	40.3754	-49	73.34	73.49	+24
7	n D	45.0750	5183.14	40.6286	-49	83.35	83.25	+21
2	n B	44.9766	5187.14	40.7239	-49	87.15	87.15	+21
4	B	44.8689	5191.32	40.8267	-49	91.26	91.29	+20
3	D	44.8188	5193.32	40.8691	-49	92.96	93.14	+20
6	B	44.2930	5214.55	41.4087	-49	14.81	14.68	+17
1 2	D	44.2419	5216.63	41.4563	-49	16.76	16.70	+16
5	D	44.1930	5218.63	41.5093	-49	18.94	18.79	+15
7	D	43.9928	5226.85	41.6988	-50	26.74	26.80	+13
3-4	B	43.9293	5229.47	41.7817	-50	30.18	29.83	+12
5	D	43.8777	5234.51	41.8894	-50	34.66	34.59	+10
4	B	43.7406	5237.30	41.9542	-50	37.36	37.33	+9
1	D	43.6973	5240.38	42.0263	-50	40.38	40.38	+9
2-3	B	43.5427	5245.57	42.1574	-50	45.88	45.73	+7
7	D	43.4924	5247.69	42.2067	-50	47.96	47.83	+6
5-6	D	43.3967	5251.72	42.2991	-50	51.86	51.79	+5
1	D	43.2901	5256.20	42.4038	-50	56.30	56.25	+3
6	D	42.9589	5270.35	42.7438	-50	70.84	70.62	+2
3	B	42.7353	5279.99	42.9646	-50	80.39	80.19	-6
1	n D	42.6542	5283.51	43.0562	-50	84.38	83.95	-8
6	D	42.3145	5298.37	43.3829	-50	98.70	98.54	-13
2	D	42.2188	5302.59	43.4734	-50	102.70	102.65	-13
2	B	41.9776	5313.30	43.7196	-50	13.66	13.48	-15
1	n D	41.9277	5315.53	43.7670	-50	15.79	15.66	-15
6	D	41.8758	5317.85	43.8262	-50	18.44	18.15	-15
1-2	D	41.8223	5320.24	43.8901	-51	21.30	20.77	-15
6	D	41.6267	5329.06	44.0755	-51	29.68	29.37	-15
3-4	B	41.3918	5339.60	44.2982	-51	39.83	39.72	-13
2	D	41.3565	5341.35	44.3428	-51	41.87	41.61	-11
3	w D	41.1681	5350.01	44.5278	-51	50.38	50.20	-8
2-3	B	41.1065	5352.85	44.5875	-51	53.14	53.00	-8
1	D	40.8959	5362.63	44.8062	-51	63.31	62.97	-2
2-3	D	40.8064	5366.81	44.9063	-51	67.99	67.40	-1
9	D	40.7695	5368.53	44.9336	-51	69.27	68.90	-1
8-9	B	40.7048	5371.57	44.9855	-51	71.71	71.64	0
2	B	40.6295	5375.11	45.0693	-51	75.66	75.39	+1
1	D	40.5892	5377.26	45.1168	-51	81.17	81.17	+1
3	B	40.2482	5383.22	45.4463	-51	93.59	93.41	+11
3	D	40.1643	5387.25	45.5351	-51	97.85	97.55	+12
2	B	40.0238	5404.02	45.6695	-51	101.33	101.18	+15
1	n D	39.9786	5406.20	45.7264	-51	107.09	106.65	+16
2-3	D	39.8862	5410.68	45.8061	-51	10.96	10.82	+17
1 2	B	39.8604	5412.42	45.8455	-51	12.87	12.65	+17
6-7	D	39.7521	5417.22	45.9381	-51	17.41	17.32	+17
2-3	D	39.6920	5420.15	46.0028	-52	20.55	20.35	+18
5-6	B	39.6286	5423.26	46.0615	-52	23.43	23.45	+18
1	D	39.5843	5425.44	46.1077	-52	25.71	25.58	+18
5	B	39.5389	5427.68	46.1533	-52	27.95	27.82	+18
4	D	39.4848	5430.34	46.2075	-52	30.63	30.49	+18
3	B	39.4474	5432.19	46.2483	-52	32.65	32.42	+19
1	n D	39.4041	5434.34	46.2889	-52	34.66	34.50	+19
4-5	B	39.3844	5445.19	46.5008	-52	45.22	45.21	+19
3	D	39.3278	5448.12	46.5619	-52	48.28	48.20	+18
2	B	39.0625	5451.40	46.6228	-52	51.34	51.37	+18
2-3	B	39.0108	5454.00	46.6817	-52	54.31	54.16	+18
1-2	D	38.9571	5456.72	46.7369	-52	57.10	56.91	+17
1	D	38.9104	5459.08	46.7855	-52	59.55	59.32	+17
3	B	38.8250	5463.10	46.8177	-52	61.19	61.19	+17
1	n D	38.7310	5468.20	46.8675	-52	63.72	63.56	+16
2	B	38.6966	5472.51	46.9339	-52	68.42	68.31	+16
1	D	38.6622	5474.43	47.0445	-52	72.74	72.63	+15
1	D	38.6282	5477.78	47.0871	-52	74.92	74.68	+14
1	D	38.5440	5477.78	47.1499	-52	78.15	77.97	+13

19 PISCUM-273 SCHJELLERUP. PLATE G 269 *Continued*

INTENSITY	CHARACTER	RED RIGHT		RED LEFT			MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave-Length Red. to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	t.m.	mm.		t.m.	t.m.		t.m.
4	B	38.4941	5480.35	47.1969	-52	80.57	80.46	+13	5480.59
2	D	38.4410	5483.09	47.2447	-52	83.03	83.06	+13	5483.19
1-2	B	.....	.....	47.5016	-52	96.37	96.37	+10	5496.47
4-5	D	38.1482	5498.31	47.5434	-52	98.56	98.44	+10	5498.54
1-2	n D	38.0711	5501.37	47.6185	-52	02.49	01.93	+9	5502.02
0-1	D	.....	.....	47.7153	-52	07.58	07.58	+8	5507.66
1	D	37.8741	5512.73	47.8232	-52	13.27	13.00	+6	5513.06
1-2	D	37.6441	5524.96	48.0453	-53	25.07	25.02	+3	5525.05
2-3	n D	37.5802	5528.38	.....	-53	.....	28.38	+3	5528.41
1	B	37.5105	5532.12	48.1754	-53	32.04	32.08	+2	5532.10
2	D	37.4711	5534.25	48.2205	-53	34.47	34.36	+1	5534.37
8	n D	37.3756	5539.40	48.3267	-53	40.20	39.80	-1	5539.79
6	B	37.2942	5543.81	48.3952	-53	43.91	43.86	-2	5543.84
3	D	37.2023	5548.81	48.4840	-53	48.73	48.77	-2	5548.75
1	B	37.0698	5554.42	48.5945	-53	54.76	54.59	-4	5554.55
1	D	37.0639	5556.38	48.6355	-53	57.00	56.68	-4	5556.64
1	n D	36.9497	5562.66	48.7458	-53	63.07	62.87	-6	5562.81
2-3	B	36.9118	5564.75	48.7787	-53	64.88	64.82	-7	5564.75
3	D	36.8736	5566.86	48.8217	-53	67.25	67.06	-7	5566.99
1	D	36.8023	5570.82	48.8835	-53	70.67	70.75	-8	5570.67
1	B	.....	.....	48.9165	-53	72.50	72.50	-8	5572.42
1	n D	.....	.....	48.9489	-53	74.30	74.30	-9	5574.21
8-9	D	36.5648	5584.07	49.1271	-53	84.24	84.16	-11	5584.05
5-6	B	36.5066	5587.33	49.1821	-53	87.33	87.33	-12	5587.21
1	D	.....	.....	49.2191	-53	89.40	89.40	-12	5589.28
1	B	36.4203	5592.20	49.2823	-53	92.96	92.58	-13	5592.45
1	n D	.....	.....	49.3260	-53	95.43	95.43	-14	5595.29
4	B	36.3247	5597.61	49.3721	-53	98.04	97.83	-14	5597.69
1	n D	36.2836	5599.94	49.4118	-53	00.29	00.12	-15	5599.97
1-2	n D	36.1205	5609.23	49.5859	-53	10.20	09.72	-17	5609.55
0-1	D	36.0020	5616.03	49.6885	-53	16.07	16.05	-18	5615.87
2	B	35.9730	5617.70	49.7208	-53	17.93	17.82	-18	5617.64
1	n D	35.9290	5620.24	49.7598	-53	20.17	20.21	-19	5620.02
2	n D	35.8487	5624.87	49.8462	-54	25.15	25.01	-20	5624.81
2	B	35.7903	5627.26	49.9022	-54	28.39	27.83	-21	5627.62
10	D	35.7484	5630.70	49.9456	-54	30.91	30.81	-21	5630.60
6	B	35.6890	5634.16	50.0033	-54	34.26	34.21	-21	5634.00
6	Head	35.6562	5636.07	50.0416	-54	36.49	36.28	-23	5636.05
6	B	35.6326	5637.45	50.0673	-54	37.99	37.72	-23	5637.49
6	B	35.5672	5641.29	50.1241	-54	41.31	41.30	-24	5641.06
3	D	35.5218	5643.95	50.1686	-54	43.92	43.94	-25	5643.69
0-1	n B	35.4712	5646.93	50.2250	-54	47.23	47.08	-25	5646.83
8	B	35.4149	5650.25	.....	-54	.....	50.25	-25	5650.00
1	D	35.3760	5654.93	50.3578	-54	55.07	55.00	-26	5654.74
2-3	D	35.2609	5659.39	50.4264	-54	59.13	59.28	-27	5659.01
1-2	B	35.0569	5671.68	50.6441	-54	72.11	71.90	-30	5671.60
2-3	D	35.0141	5674.16	50.6803	-54	74.28	74.22	-30	5673.92
1-2	D	34.9730	5676.63	50.7203	-54	76.69	76.66	-31	5676.35
1	B	34.9259	5679.48	50.7638	-54	79.31	79.40	-31	5679.09
1	D	34.8730	5685.10	50.8493	-54	84.47	84.79	-31	5684.48
4	wn B	34.6899	5693.82	51.0091	-54	94.17	94.00	-33	5693.67
0-1	D	34.6338	5697.13	51.0672	-54	97.72	97.43	-33	5697.10
3	B	34.4907	5706.05	51.1990	-54	05.80	05.93	-35	5705.58
2	D	34.4483	5708.66	51.2438	-54	08.55	08.61	-35	5708.26
2	B	34.4073	5711.20	51.2838	-54	11.02	11.11	-35	5710.76
1	D	34.3754	5713.18	51.3171	-54	13.07	13.13	-36	5712.77
2	B	34.3453	5715.05	51.3577	-54	15.58	15.32	-36	5714.96
4	D	34.2939	5718.24	51.3960	-54	17.96	18.10	-36	5717.74
2	B	34.1903	5724.71	51.5036	-54	24.65	24.68	-37	5724.31
3	D	34.0749	5731.94	51.6266	-54	32.34	32.14	-37	5731.77
2	n D	33.8804	5744.23	51.8313	-55	45.23	44.73	-39	5744.34
1	n B	.....	.....	51.8584	-55	46.95	46.95	-39	5746.56
1	n D	33.7952	5749.64	51.8955	-55	49.30	49.47	-39	5749.08
3	n B	33.6737	5757.41	52.0189	-55	57.16	57.29	-40	5756.89
2	n D	33.5835	5763.21	52.0912	-55	61.78	62.50	-40	5762.10
3	wn B	33.5161	5767.55	52.1736	-55	67.07	67.31	-41	5766.90
1	n B	33.3802	5776.36	52.3036	-55	75.46	75.91	-42	5775.49
1	n D	.....	.....	52.3455	-55	78.18	78.18	-42	5777.76

## 19 PISCUM=273 SCHJELLERUP. PLATE G 269—Continued

Intensity	Filter	Line	Blue Region		Red Line			Mean Wave Length		
			Mean Scale Reading	Wave Length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave Length Red. to Sun	Uncorrected	Cor. from Curve	Corrected
			mm.	Å.	mm.	Å.	Å.	Å.	Å.	Å.
1-2		B	33.3122	5780.79	52.3708	-55	80.40	80.60	-42	5780.18
2		n D	33.2751	5785.70	52.4564	-55	85.39	85.55	-42	5785.13
1-2		D	33.0335	5790.10	.....	-55	.....	90.10	-44	5798.66
1		n D	.....	.....	53.0274	-55	23.13	23.13	-44	5822.69

## 19 PISCUM=273 SCHJELLERUP. PLATE G 293

1899, January 27, G. M. T. 13.0. Hour angle, W 3.9. Star good; comparison good.

			mm.	t. m.	mm.		t. m.	t. m.		t. m.
1 2	as	D	44.3276	5173.18	43.8093	-40	73.51	73.35	+13	5173.48
2		D	44.0579	5183.83	44.0609	-40	83.46	83.65	+12	5183.77
1		n D	43.9335	5188.78	.....	-40	.....	88.78	+11	5188.89
1 2		B	43.8898	5190.52	44.2470	-40	90.88	90.70	+11	5190.81
2		n D	43.8346	5192.73	44.2902	-40	92.61	92.67	+10	5192.77
2		n B	43.7226	5197.22	44.3986	-40	96.96	97.09	+10	5197.19
1		n B	43.3026	5214.24	44.8348	-40	14.66	14.45	+9	5214.54
1		D	43.2445	5216.61	44.8875	-40	16.81	16.71	+7	5216.78
1		B	43.2021	5218.35	44.9238	-40	18.30	18.33	+7	5218.40
1		n D	43.0283	5225.50	.....	-40	.....	25.50	+5	5225.55
1 2		D	42.8259	5231.88	45.3063	-40	34.11	34.00	+4	5231.01
1		D	42.6896	5239.56	45.4421	-40	39.78	39.67	+3	5239.70
1 2		B	42.5729	5244.45	45.5789	-40	45.52	44.99	+1	5245.00
1		D	42.5058	5247.28	45.6200	-40	47.25	47.27	0	5247.27
1		B	42.4700	5248.78	45.6770	-40	49.66	49.22	0	5249.22
3		D	42.4172	5251.01	45.7135	-40	51.20	51.11	0	5251.11
1		D	42.3108	5255.51	45.8297	-40	56.12	55.82	-1	5255.81
7		n D	41.9689	5270.10	46.1627	-41	70.35	70.23	-3	5270.20
2 3		n B	41.7429	5279.85	46.3930	-41	80.30	80.08	-5	5280.03
1 2		D	41.6892	5282.19	46.4431	-41	82.48	82.34	-5	5282.29
3		D	41.3253	5298.11	46.8156	-41	98.80	98.46	-5	5298.41
1		n D	41.2195	5302.78	46.9097	-41	02.96	02.87	-5	5302.82
1 2		B	41.1673	5306.09	46.9693	-41	05.60	05.85	-5	5305.80
2		n B	40.9915	5312.92	47.1470	-41	13.52	13.22	-5	5313.17
2		n D	40.9380	5315.31	47.1947	-41	15.66	15.49	-5	5315.44
1		n B	40.8838	5317.74	47.2398	-41	17.68	17.71	-5	5317.66
2		n D	40.8139	5320.88	47.3166	-41	21.13	21.00	-5	5320.95
1		n D	.....	.....	47.4102	-41	25.35	25.35	-4	5325.31
2 3		D	40.6111	5328.66	47.4889	-41	28.91	28.79	-3	5328.76
1 2		B	40.4101	5339.90	47.7265	-41	39.73	39.46	-1	5339.45
1		D	40.3725	5340.90	47.7637	-41	41.43	41.17	0	5341.17
1		B	40.1804	5349.73	47.9589	-41	50.41	50.07	+1	5350.08
2	as	B	.....	.....	48.0083	-41	52.69	52.69	+1	5352.70
2		B	39.7770	5368.49	48.3496	-41	68.59	68.54	+5	5368.59
5 6	w	D	39.7130	5371.49	48.4172	-41	71.77	71.63	+6	5371.69
2	as	D	39.6435	5376.76	48.4854	-41	74.98	75.87	+6	5375.93
1	as	B	39.5873	5377.40	48.5423	-42	77.65	77.53	+7	5377.60
1	as	B	39.5398	5379.65	48.5980	-42	80.35	80.00	+8	5380.08
1		D	39.3157	5380.31	48.8188	-42	90.80	90.56	+9	5380.65
1		D	39.1702	5397.28	49.9671	-42	97.91	97.60	+10	5397.70
1 2		D	38.9884	5406.06	49.1493	-42	06.71	06.39	+10	5406.49
2 3		B	38.8085	5410.42	49.2295	-42	10.46	10.44	+11	5410.55
1 2		B	38.8655	5412.02	49.2717	-42	12.65	12.39	+11	5412.50
1		B	38.8269	5413.70	49.3012	-42	14.09	13.90	+11	5414.01
1		B	38.7718	5416.59	49.3638	-42	17.14	16.87	+11	5416.98
2		n D	38.7113	5419.55	49.4215	-42	19.37	19.76	+11	5419.87
1		n B	38.6454	5422.78	49.4905	-42	23.34	23.06	+12	5423.18
1		D	.....	.....	49.5234	-42	21.97	21.97	+12	5425.09
2 3		B	38.5804	5427.01	49.5875	-42	28.13	27.57	+12	5427.69
1		D	38.4954	5430.19	49.6261	-42	30.18	30.18	+12	5430.30
2		B	38.4698	5431.60	49.6715	-42	32.28	32.09	+12	5432.21
1		D	38.4253	5433.64	49.7054	-42	34.96	34.80	+12	5433.92
1		n D	38.3972	5438.52	49.8043	-42	38.87	38.70	+12	5438.82
1		B	38.3620	5441.77	49.9298	-42	45.14	44.96	+11	5445.07
10		D	38.1415	5447.79	49.9861	-42	47.86	47.88	+11	5447.90

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 283 -Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH			
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave-Length Red. to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	t.m.	mm.		t.m.	t.m.		t.m.
2	B	38.0855	5450.60	50.0365	-42	50.49	50.55	+10	5450.65
2-3	B	38.0813	5453.34	50.1014	-42	53.76	53.55	+10	5453.65
3 4	D	37.9668	5456.59	50.1614	-42	56.78	56.69	+10	5456.79
2	B	37.9252	5458.69	50.2067	-42	59.08	58.87	+10	5458.97
2	D	37.8887	5460.54	50.2453	-42	61.03	60.79	+10	5460.89
1-2	B	37.8473	5462.64	50.2819	-42	62.89	62.67	+10	5462.77
1	D	.....	.....	50.3803	-42	67.90	67.90	+9	5467.99
3	wn B	37.6671	5471.83	50.4713	-42	72.54	72.19	+8	5472.27
1-2	D	37.6181	5474.34	50.5081	-42	74.43	74.39	+8	5474.47
1	B	.....	.....	50.6344	-42	80.92	80.92	+7	5480.99
2	D	37.4621	5482.37	50.6697	-42	82.75	82.56	+7	5482.63
2	B	37.2032	5495.80	50.9215	-43	95.79	95.80	+5	5495.85
4 5	D	37.1634	5497.88	50.9682	-43	98.27	98.08	+5	5498.13
1	D	37.0861	5501.93	51.0444	-43	02.23	02.08	+4	5502.12
1	B	36.9948	5506.72	51.1359	-43	07.04	06.89	+3	5506.92
3	B	36.9370	5509.77	51.1910	-43	09.94	09.86	+3	5509.89
1-2	n D	36.8839	5512.58	51.2400	-43	12.53	12.56	+1	5512.57
0-1	D	36.6695	5523.98	51.4623	-43	24.35	24.17	-1	5524.16
2	B	36.5224	5531.86	.....	-43	.....	31.86	-3	5531.83
1-2	D	36.4876	5533.73	.....	-43	.....	33.73	-3	5533.70
10	D	36.3832	5539.37	51.7470	-43	39.64	39.51	-5	5539.46
2-3	B	36.3061	5543.54	51.8141	-43	43.27	43.41	-6	5543.35
1	D	36.2272	5547.83	51.9171	-43	48.87	48.35	-7	5548.28
1	D	36.1444	5552.35	51.9874	-43	52.71	52.53	-8	5552.45
2	B	36.1144	5553.99	52.0148	-43	54.20	54.10	-9	5554.01
1	D	36.0761	5556.09	52.0584	-43	56.59	56.34	-9	5556.25
1	B	36.0396	5558.09	52.0899	-43	58.32	58.21	-9	5558.12
2	D	35.9639	5562.25	52.1680	-43	62.60	62.43	-11	5562.32
1-2	B	35.9218	5564.57	52.2075	-43	64.79	64.68	-11	5564.57
1	D	35.8853	5566.59	52.2483	-43	67.04	66.82	-12	5566.70
1	D	35.8228	5570.08	52.3015	-43	69.98	70.03	-12	5569.91
1	B	35.7926	5571.72	52.3337	-43	71.76	71.74	-13	5571.61
1	D	35.7671	5573.14	52.3654	-43	73.52	73.33	-13	5573.20
1	B	35.7058	5576.55	52.4213	-43	76.63	76.59	-14	5576.45
1	D	35.6281	5580.89	52.4934	-43	80.65	80.77	-15	5580.62
10	B	35.5743	5583.90	52.5574	-43	84.23	84.07	-16	5583.91
4-5	B	35.5167	5587.13	52.6070	-43	87.01	87.07	-17	5586.90
1	D	35.4781	5589.30	52.6475	-43	89.29	89.30	-17	5589.13
2	B	35.4241	5592.32	52.6989	-43	92.18	92.25	-18	5592.07
1	D	35.3945	5594.01	52.7466	-43	94.87	94.44	-18	5594.26
3 4	B	35.3327	5597.51	52.7963	-43	97.68	97.60	-19	5597.41
1	D	35.2937	5599.72	52.8369	-43	99.98	99.85	-19	5599.66
1	D	35.1307	5609.00	53.0030	-43	09.44	09.22	-20	5609.02
0-1	D	35.0075	5616.06	53.1101	-44	15.56	15.81	-21	5615.60
2 3	n D	34.9350	5620.23	53.1898	-44	20.14	20.19	-22	5619.97
2	B	34.8480	5625.26	53.2680	-44	24.65	24.97	-23	5624.74
1	B	34.7991	5628.09	53.3223	-44	27.79	27.94	-23	5627.71
1-2	B	34.7494	5630.98	53.3754	-44	30.88	30.93	-23	5630.70
10	D	34.6859	5634.68	53.4411	-44	34.70	34.69	-23	5634.46
	Head	34.6329	5636.60	53.4736	-44	36.59	36.60	-24	5636.36
3	B	34.6305	5637.91	53.4898	-44	37.53	37.72	-24	5637.48
2-3	B	34.5708	5641.41	53.5593	-44	41.60	41.51	-25	5641.26
1	D	34.5285	5643.89	53.5987	-44	43.91	43.90	-25	5643.65
1	n B	.....	.....	53.6574	-44	47.36	47.36	-25	5647.11
1	n D	34.4224	5650.13	53.7002	-44	49.88	50.01	-25	5649.76
1	B	34.3840	5652.40	53.7427	-44	52.38	52.39	-26	5652.13
1	B	34.3380	5655.13	53.7950	-44	55.50	55.28	-26	5655.02
1-2	D	34.2732	5658.97	53.8547	-44	59.02	59.00	-27	5658.73
3	B	34.0156	5674.37	54.1068	-44	74.06	74.22	-28	5673.94
1	n D	33.9817	5676.41	54.1516	-44	76.76	76.59	-28	5676.31
1	B	33.9293	5679.57	54.2020	-44	79.79	79.68	-29	5679.39
1	B	33.8439	5684.73	54.2866	-44	84.90	84.82	-30	5684.52
1	n D	33.7948	5687.71	54.3396	-44	88.11	87.91	-30	5687.61
3-4	B	33.6891	5694.15	54.4430	-44	94.40	94.28	-30	5693.98
1-2	D	33.6425	5696.99	54.4863	-44	97.04	97.02	-30	5696.72
3	B	33.5005	5705.71	54.6349	-44	06.15	05.93	-31	5705.62
2	n D	33.4497	5708.84	54.6791	-44	08.87	08.86	-31	5708.55
2	B	33.4126	5711.13	54.7160	-44	11.15	11.14	-31	5710.83

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 293 - Continued

Intensity	Character	RED RIGHT		RED LEFT			MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Red. to Sun	Wave-Length Red. to Sun	Uncorrected	Cor. from Curve	Corrected
		mm.	μm.	mm.	μm.	μm.	μm.	μm.	μm.
1	D	33.3742	5713.51	54.7594	-44	13.83	13.67	-32	5713.35
5	w B	33.3120	5717.37	54.8116	-44	17.07	17.22	-32	5716.90
1	n D	33.2490	5721.27	54.8796	-44	21.29	21.28	-33	5720.95
2	B	33.1980	5724.47	54.9301	-44	24.44	24.46	-33	5724.13
3	n D	33.0843	5731.58	55.0491	-45	31.87	31.73	-33	5731.40
1	n D	32.8723	5744.96	55.2605	-45	45.19	45.08	-33	5744.75
1	n B	32.8321	5747.51	55.2967	-45	47.48	47.50	-35	5747.15
1	n D	32.7885	5750.28	55.3435	-45	50.45	50.37	-35	5750.02
2 3	w B	32.6799	5757.22	55.4555	-45	57.59	57.41	-35	5757.06
1	n D	32.5897	5763.00	55.5380	-45	62.87	62.94	-35	5762.59
1-2	w B	32.5096	5768.16	55.6138	-45	67.75	67.96	-36	5767.60
1	n D	32.4652	5771.03	55.6664	-45	71.14	71.09	-36	5770.73
1	n B	32.3870	5776.09	55.7438	-45	76.79	76.44	-36	5776.08
1	n D	32.3565	5778.07	55.7760	-45	78.23	78.15	-36	5777.79
1	n B	32.3219	5780.33	55.8012	-45	79.87	80.10	-37	5779.73
1	n D	32.0596	5799.02	56.0927	-45	98.93	98.98	-37	5798.61

## 19 PISCUM = 273 SCHJELLERUP. PLATE G 357

1899, December 19, G.M.T. 12<sup>h</sup> 8. Hour angle, W. 1<sup>h</sup> 2. Star excellent; comparison excellent.

Intensity	Character	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Wave-Length Reduced to Sun	Uncorrected	Cor. from Curve	Corrected
		mm.	μm.	mm.	μm.	μm.	μm.	μm.
1	n D	36.5069	5168.82	47.9644	5168.97	68.90	-33	5168.57
2 3	n D	36.1711	5173.68	48.0796	5173.92	73.80	-32	5173.48
1	B	36.1344	5187.46	48.1589	5189.16	87.46	-27	5187.19
1 2	n D	36.0803	5189.28	48.5632	5193.47	89.22	-27	5188.95
1	n B	35.9849	5193.64	48.6570	5197.36	93.56	-25	5193.31
10	n D	35.8963	5197.32	48.9230	5208.40	97.34	-24	5197.10
1	n D	35.6390	5208.18	49.3305	5225.73	108.29	-20	5208.00
3	w B	35.2121	5226.14	49.5258	5234.08	125.94	-14	5225.80
3	n D	35.0231	5234.24	49.5855	5236.99	134.16	-12	5234.04
2 4	w B	34.9654	5236.73	49.6537	5239.67	136.86	-11	5236.75
1 2	n D	34.8983	5239.62	49.8388	5247.61	147.59	-6	5247.53
5	D	34.7153	5247.56	49.9220	5251.24	151.25	-5	5251.20
5 6	D	34.6308	5251.25	50.3631	5270.67	170.63	-1	5270.62
1	D	34.1920	5270.58	50.5654	5279.69	179.00	0	5279.60
1	n B	33.9622	5279.50	50.6377	5282.93	183.11	+1	5283.12
2	w B	33.9076	5283.29	50.9641	5297.69	197.82	+4	5297.86
2	n D	33.5840	5297.94	51.0712	5302.58	202.59	+5	5302.64
2	n B	33.4820	5302.59	51.1280	5305.18	205.03	+5	5305.08
2	n B	33.4323	5304.87	51.3014	5313.15	213.15	+6	5313.21
3	n B	33.2535	5313.14	51.3428	5315.07	215.21	+6	5315.27
3	n D	33.2049	5315.34	51.3978	5317.61	217.64	+8	5317.72
3	n B	33.1548	5317.66	51.4715	5321.03	221.09	+9	5321.18
3	n D	33.0797	5321.14	51.5611	5325.20	225.08	+10	5325.18
2	n D	32.9979	5324.95	51.6419	5328.98	228.82	+11	5328.93
1	n D	32.9185	5328.66	51.8044	5336.66	236.78	+12	5336.90
1 2	n B	32.7174	5336.89	51.8536	5338.93	238.99	+12	5339.11
2 3	n D	32.6976	5339.05	51.8987	5341.06	241.09	+13	5341.22
2	n D	32.6739	5341.12	52.0750	5349.43	249.60	+13	5349.73
2	n B	32.4780	5349.77	52.1396	5352.51	252.29	+14	5352.43
1	n B	32.4245	5352.07	52.3518	5362.69	262.54	+15	5362.69
1 2	n D	32.2864	5362.30	52.4321	5366.57	266.45	+16	5366.61
1	D	32.1267	5371.11	52.5245	5371.05	271.08	+17	5371.25
1	D	32.0891	5371.67	52.6028	5374.85	274.76	+17	5374.93
5	B	31.9549	5374.67	52.6504	5377.17	277.15	+17	5377.32
2	D	31.8847	5377.12	52.7000	5379.60	279.59	+18	5379.77
3	n B	31.8043	5379.58	52.9236	5380.58	280.57	+19	5380.76
3	n D	31.6849	5380.55	53.0572	5397.20	297.16	+19	5397.35
1	D	31.4984	5397.11	53.2310	5405.86	305.85	+20	5406.05
4	D	31.3236	5405.83					

## 19 PISCUM=273 SCHJELLERUP. PLATE G 357 Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean	Wave-Length	Mean	Wave-Length	Uncor-	Cor.	Corrected
		Scale Reading	Reduced to Sun	Scale Reading	Reduced to Sun	rected	from Curve	
		mm.	t.m.	mm.	t.m.	t.m.		t.m.
4	D	31.2489	5409.57	53.3114	5409.88	09.73	+21	5409.94
1	D	31.1592	5414.07	53.3920	5413.93	14.00	+21	5414.21
6-7	B	31.1020	5416.96	53.4507	5416.90	16.93	+21	5417.14
2-3	n D	31.0479	5419.70	53.5050	5419.64	19.67	+22	5419.89
2-3	B	30.9895	5422.65	53.5654	5422.70	22.68	+22	5422.90
1	D	30.9545	5424.43	53.6026	5424.59	24.51	+22	5424.73
3	D	30.8475	5429.88	53.7055	5429.83	29.86	+22	5430.08
2	D	30.7724	5433.72	53.7791	5433.59	33.66	+22	5433.88
2	D	30.6796	5438.48	53.8684	5438.17	38.33	+22	5438.55
2	B			53.9894	5444.41	44.41	+22	5444.63
5-6	D	30.4977	5447.87	54.0422	5447.14	47.51	+22	5447.73
1-2	B	30.4435	5450.68	54.1060	5450.44	50.56	+23	5450.79
2	B	30.3931	5453.30	54.1616	5452.52	52.91	+23	5453.14
4	D	30.3307	5456.55	54.2207	5456.41	56.48	+23	5456.71
1	B	30.2931	5458.51	54.2603	5458.48	58.50	+23	5458.73
2	D	30.2570	5460.40	54.2961	5460.35	60.38	+23	5460.61
1-2	B	30.2112	5462.80	54.3419	5462.76	62.78	+23	5463.01
1-2	B	30.1771	5464.59	54.3765	5464.57	64.58	+23	5464.81
2	D	30.1373	5466.69	54.4163	5466.66	66.67	+23	5466.90
2	B	30.0300	5471.87	54.5152	5471.88	71.88	+23	5472.11
2	n D	29.9979	5474.04	54.5564	5474.06	74.05	+23	5474.28
2	n D	29.9280	5477.75	54.6266	5477.78	77.77	+23	5478.00
2-3	D	29.8442	5482.20	54.7100	5482.22	82.21	+23	5482.44
3	D	29.5614	5497.38	54.9963	5497.58	97.48	+23	5497.71
2	D	29.4792	5501.82	55.0732	5501.74	01.78	+23	5502.01
1	D	29.3828	5507.05	55.1692	5506.95	07.00	+23	5507.23
1-2	n D	29.2880	5512.22	55.2618	5511.99	12.11	+23	5512.34
1	n D	29.0767	5523.82	55.4749	5523.69	23.76	+23	5523.99
1-2	n D	29.0086	5527.58	55.5492	5527.79	27.69	+23	5527.92
2	n B	28.9425	5531.24	55.6192	5531.67	31.46	+22	5531.68
1	D	28.9077	5533.17	55.6468	5533.21	33.19	+22	5533.41
7	D	28.7985	5539.25	55.7660	5539.65	39.45	+22	5539.67
2	n D	28.6479	5547.69	55.9165	5548.28	47.99	+21	5548.20
1	n D	28.5716	5551.98	55.9824	5552.00	51.98	+21	5552.19
3	B	28.5389	5553.83	56.0157	5553.88	53.86	+20	5554.06
1-2	D	28.5065	5555.66	56.0508	5555.86	55.76	+20	5555.96
2	D	28.3946	5562.00	56.1618	5562.16	62.08	+20	5562.28
2	B	28.3622	5563.85	56.1950	5564.05	63.95	+20	5564.15
2	B	28.3225	5566.11	56.2297	5566.02	66.07	+20	5566.27
1	D	28.2556	5569.93	56.2996	5570.01	69.97	+20	5570.17
1	B	28.2357	5571.07	56.3232	5571.37	71.22	+19	5571.41
1	D	28.2064	5572.75	56.3553	5573.21	72.98	+19	5573.17
1	D	28.1550	5575.70	56.4049	5576.06	75.88	+19	5576.07
8	D	28.0143	5583.81	56.5377	5583.72	83.77	+18	5583.95
4	B	27.9691	5586.43	56.5891	5586.70	86.57	+18	5586.75
2	n D	27.9385	5588.20	56.6212	5588.56	88.38	+18	5588.56
1-2	n B	27.8771	5591.77	56.6850	5592.27	92.02	+16	5592.18
1-2	n D	27.8519	5593.24	56.7174	5594.16	93.70	+16	5593.86
1-2	n B	27.7870	5597.03	56.7644	5596.90	96.97	+16	5597.13
1	n D	27.7582	5598.71	56.8030	5599.10	98.91	+14	5599.05
3	n D	27.5787	5609.26	56.9777	5609.43	09.35	+13	5609.48
1	n D	27.4832	5614.91	57.0721	5615.02	14.97	+12	5615.09
3-4	n D	27.3989	5619.91	57.1574	5620.08	20.00	+10	5620.10
4-5	n D	27.3243	5624.36	57.2314	5624.50	24.43	+9	5624.52
10	D	27.1626	5634.05	57.3846	5633.65	33.85	+7	5633.92
Head		27.1260	5636.23	57.4310	5636.40	36.32	+7	5636.39
1	B	27.1109	5637.16	57.4475	5638.07	37.62	+7	5637.69
1-2	n D	27.0499	5640.84	57.5064	5641.03	40.94	+7	5641.01
1	B	26.9853	5644.75	57.5663	5644.66	44.71	+4	5644.75
1	n B	26.9614	5646.20	57.5912	5646.17	46.19	+4	5646.23
1	D	26.9033	5649.74			49.74	+3	5649.77
1	B	26.8662	5652.00	57.6893	5652.14	52.07	+3	5652.10
2	B	26.8165	5655.03	57.7445	5655.51	55.27	+2	5655.29
3	n D	26.7738	5657.64	57.7881	5658.18	57.91	+2	5657.93
2	D	26.5594	5670.84	57.9960	5670.99	70.92	+1	5670.93
3	B	26.5217	5673.18	58.0379	5673.59	73.39	-4	5673.35
2-3	D	26.4767	5675.97	58.0800	5676.20	76.09	-4	5676.05
1-2	B	26.4304	5678.84	58.1298	5679.30	79.07	-5	5679.02

## 15 PISCUM=273 SCHJELLERUP. PLATE G 357 - Continued

INTENSITY	CHARACTER	RED RIGHT		RED LEFT		MEAN WAVE-LENGTH		
		Mean Scale Reading	Wave-Length Reduced to Sun	Mean Scale Reading	Wave-Length Reduced to Sun	Uncor- rected	Cor. from Curve	Corrected
		mm.	t.m.	mm.	t.m.	t.m.		t.m.
1	E	26.3504	5683.47	58.2076	5684.15	83.81	- 6	5683.75
1-2	n B	26.1981	5693.39	58.3626	5693.88	93.64	- 7	5693.57
2	n D	26.1487	5696.50	58.4069	5696.68	96.59	-10	5696.49
3	B	26.0122	5705.11	58.5441	5705.37	05.26	-13	5705.13
2-3	D	25.9681	5707.94	58.5862	5708.05	08.00	-16	5707.84
1-2	B	25.9312	5710.29	58.6267	5710.63	10.46	-16	5710.30
1-2	D	25.8981	5712.40	58.6644	5713.08	12.74	-17	5712.57
3	B	25.8323	5716.61	58.7269	5717.09	17.45	-18	5717.27
2	D	25.7591	5721.31	58.7931	5721.29	21.30	-18	5721.12
2	B	25.7211	5723.75	58.8383	5724.20	23.98	-18	5723.80
1-2	n D			58.9537	5731.65	31.65	-21	5731.44
3	n D	25.4132	5743.73	59.1507	5744.48	44.11	-26	5743.85
2-3	n D	25.1178	5763.17	59.4328	5763.07	63.12	-33	5762.79
4	n D	24.9911	5771.59	59.5667	5771.98	71.79	-35	5771.44
1	B	24.9298	5775.69	59.6340	5776.48	76.09	-35	5775.74
1	D	24.8977	5777.84	59.6633	5778.45	78.15	-37	5777.78
1	B	24.8696	5779.72	59.6891	5780.18	79.95	-40	5779.55
1-2	D	24.5942	5798.32	59.9630	5798.70	98.56	-50	5778.06
1	D	24.2375	5822.81	60.3219	5823.36	23.09	-40	5822.69

## 19 PISCUM=273 SCHJELLERUP

Means of Two Plates

PLATE G 364			PLATE G 345			MEAN WAVE-LENGTH		
Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		t.m.			t.m.	t.m.		t.m.
1	D	4375.87	.....	.....	.....	75.81	+3	4375.84
10	w D	4384.11	.....	.....	.....	84.05	+3	4384.08
2-3	n D	4390.36	.....	.....	.....	90.30	+3	4390.33
5	w D	4395.05	1	w D	4394.55	94.80	+3	4394.83
.....	.....	.....	1	D	4397.56	97.62	+3	4397.65
1	n D	4401.16	.....	.....	.....	00.84	+3	4400.87
3	B	4402.50	3	D	4400.51	02.44	+3	4402.47
10	w D	4405.02	4	D	4401.88	04.95	+3	4404.98
2	D	4408.66	4	D	4408.30	08.48	+3	4408.51
.....	.....	.....	1	D	4412.20	12.26	+3	4412.29
4-5	n D	4415.28	2	wn D	4414.09	15.14	+3	4415.17
.....	.....	.....	2-3	wn D	4420.51	20.57	+3	4420.60
1	D	4423.22	1-2	D	4422.85	23.04	+3	4423.07
1	B	4426.84	.....	.....	.....	26.78	+3	4426.81
2	n D	4427.70	1-2	D	4427.21	27.46	+3	4427.49
3	n D	4430.28	1-2	n D	4430.01	30.15	+3	4430.18
4-5	n D	4435.71	3	n D	4435.27	35.49	+3	4435.52
1	D	4438.25	1	n D	4437.94	38.10	+3	4438.13
.....	.....	.....	2	B	4438.80	38.86	+3	4438.89
.....	.....	.....	2-3	n D	4444.36	44.42	+3	4444.45
1-2	n D	4447.26	1	n D	4446.96	47.11	+3	4447.14
3	n B	4448.80	2	n B	4448.49	48.65	+3	4448.68
4-5	n D	4450.15	5	n D	4449.70	49.93	+3	4449.96
.....	.....	.....	1	D	4453.17	53.23	+3	4453.26
2	n D	4455.41	3	n D	4455.05	55.23	+3	4455.26
3-4	n D	4462.24	2	n D	4462.04	62.14	+3	4462.17
4	n B	4463.99	3	n B	4464.02	64.01	+3	4464.04
1	n D	4468.39	1	D	4465.13	65.26	+3	4465.29
1	n D	4469.42	1-2	D	4468.02	68.92	+3	4468.95
.....	.....	.....	1	D	4472.16	72.22	+3	4472.25
.....	.....	.....	1-2	n D	4475.43	75.49	+3	4475.52

## 19 PISCUM = 273 SCHJELLERUP—Continued

PLATE G 29			PLATE G 33			MEAN WAVE-LENGTH		
Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		t.m.			t.m.	t.m.		t.m.
1-2	n D	4479.97	1 2	n D	4479.96	79.97	+3	4480.00
2	D	4482.09	3	n D	4482.23	82.16	+3	4482.19
3	B	4483.80	2	n B	4483.38	83.59	+3	4483.62
2	B	4486.06	.....	.....	.....	86.00	+3	4486.03
1-2	D	4487.60	1-2	n D	4487.47	87.54	+3	4487.57
3	B	4488.64	.....	.....	.....	88.58	+3	4488.61
2-3	D	4489.75	2-3	D	4489.68	89.72	+3	4489.75
6	D	4497.13	3	n D	4496.85	96.99	+3	4497.02
2 3	D	4501.77	5	n D	4501.72	01.75	+3	4501.78
6	n D	4506.78	6 7	D	4506.70	06.74	+3	4506.77
1	D	4509.64	1	D	4509.83	09.74	+3	4509.77
.....	wn D	4512.87	.....	wn D	4512.58	12.73	+3	4512.76
2	n B	4517.08	.....	.....	.....	17.02	+3	4517.05
4	D	4518.28	3	D	4518.20	18.24	+3	4518.27
1	D	4520.57	.....	.....	.....	20.51	+3	4520.54
3-4	B	4521.69	.....	.....	.....	21.63	+3	4521.66
5	D	4523.00	3	D	4522.93	22.97	+3	4523.00
6	w D	4527.44	4	nn D	4527.07	27.26	+3	4527.29
2-3	n D	4531.38	2	D	4531.26	31.32	+3	4531.35
3-4	wn D	4535.87	9	wn D	4535.40	35.64	+3	4535.67
3	B	4537.40	3	n B	4537.18	37.29	+3	4537.32
3	B	4539.00	2	B	4538.94	38.97	+3	4539.00
3	D	4540.51	1	D	4540.26	40.39	+3	4540.42
1	D	4542.78	.....	.....	.....	42.72	+3	4542.75
2	B	4544.13	.....	.....	.....	44.07	+3	4544.10
3	n B	4547.82	.....	.....	.....	47.76	+3	4547.79
5	wn D	4549.23	5	wn D	4549.21	49.22	+3	4549.24
10	w D	4553.57	.....	w D	4553.45	53.51	+3	4553.54
Limits }		4551.98	.....	.....	.....	51.92	+3	4552.0
3	D	4554.81	.....	.....	.....	54.75	+3	4554.8
3	n B	4560.31	3	nn D	4560.40	60.36	+3	4560.39
2 3	D	4561.94	.....	.....	.....	61.88	+3	4561.91
1	D	4563.62	2-3	D	4563.02	63.32	+3	4563.35
.....	w D	4565.62	1-2	n D	4565.77	65.70	+3	4565.73
.....	.....	4571.69	9	w D	4571.57	71.63	+3	4571.66
.....	.....	.....	3	n D	4575.16	75.22	+3	4575.25
.....	.....	.....	3 4	n D	4577.48	77.54	+3	4577.57
.....	.....	.....	Head	.....	4578.0	78.1	+3	4578.1
.....	.....	.....	1	D	4580.33	80.39	+3	4580.42
.....	.....	.....	1	D	4581.84	81.90	+3	4581.93
2	n B	4583.70	.....	.....	.....	83.64	+3	4583.67
1	D	4584.68	1-2	D	4584.39	84.54	+3	4584.57
1	B	4585.44	.....	.....	.....	85.38	+3	4585.41
2	n D	4586.37	2	n D	4586.28	86.34	+3	4586.37
1	D	4590.99	1	n D	4590.98	90.99	+3	4591.02
2-3	n D	4594.39	2	n D	4594.23	94.31	+3	4594.34
2	n B	4595.83	.....	.....	.....	95.77	+3	4595.80
.....	.....	.....	1	n D	4597.43	97.49	+3	4597.52
1	D	4600.90	2	n D	4600.72	00.81	+3	4600.84
10	w D	4606.99	8	wn D	4606.66	06.83	+3	4606.86
.....	.....	.....	1	n D	4609.98	10.04	+3	4610.07
1-2	B	4612.35	.....	.....	.....	12.29	+3	4612.32
1	n D	4613.74	1-2	nn D	4613.79	13.77	+3	4613.80
3	B	4615.01	3	B	4614.86	14.92	+3	4614.95
2	D	4616.39	3	D	4616.13	16.26	+3	4616.29
6	B	4617.84	6	B	4617.69	17.77	+3	4617.80
4	D	4619.73	5-6	D	4619.56	19.65	+3	4619.68
3	B	4621.37	4-5	B	4621.26	21.32	+3	4621.35
1	n D	4622.76	2	n D	4622.79	22.78	+3	4622.81
4 5	wn D	4629.28	5	D	4629.18	29.23	+3	4629.26
3	B	4631.25	5	B	4630.99	31.12	+3	4631.15
1	D	4634.64	.....	.....	.....	34.58	+3	4634.61
2	D	4637.49	.....	.....	.....	37.43	+3	4637.46
3	B	4638.63	3	B	4638.80	38.72	+3	4638.75
5 6	D	4640.47	6	D	4640.04	40.26	+3	4640.29
3	n B	4641.76	4	n B	4641.66	41.71	+3	4641.74
.....	wn D	4645.86	.....	.....	.....	45.80	+3	4645.83
2-3	B	4652.83	.....	.....	.....	52.77	+3	4652.80

## 19 PISCUM = 273 SCHJELLERUP—Continued

PLATE G 294			PLATE G 303			MEAN WAVE-LENGTH		
Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		t. m.			t. m.	t. m.		t. m.
1	D	4653.89	1	D	4654.13	54.01	+3	4654.04
1	D	4656.39	1	D	4656.81	56.60	+3	4656.63
	w B	4660.94				60.88	+3	4660.91
1-2	D	4664.17				64.11	+3	4664.14
2	n B	4665.44				65.38	+3	4665.41
3	wn D	4668.11				68.05	+3	4668.08
4	D	4675.16				75.10	+3	4675.13
1	D	4682.32				82.26	+3	4682.29
1	n D	4688.46				88.40	+3	4688.43
1	n D	4691.15				91.09	+3	4691.12
3-4	n D	4696.59				96.53	+3	4696.56
				Head	4697.1	97.2	+3	4697.2
6	wn D	4714.64				14.58	+3	4714.61
				Head	4714.7	14.8	+3	4714.8
1-2	n D	4722.72				22.66	+3	4722.69
10	w D	4736.07	10	n D	4736.38	36.23	+3	4736.26
	Head	4737.70		Head	4737.54	37.62	+3	4737.65
7-8	B	4738.65	8	B	4738.53	38.59	+3	4738.62
			1	D	4739.76	39.82	+3	4739.85
4-5	n D	4744.06	10	w D	4743.76	43.91	+3	4743.94
7	B	4746.69	6	B	4746.28	46.49	+3	4746.52
1	n D	4749.77	2-3	n D	4749.40	49.59	+3	4749.62
			3	B	4754.98	55.04	+3	4755.07
			1	D	4756.14	56.20	+3	4756.23
			2	B	4756.85	56.91	+3	4756.94
1-2	wn D	4758.49	4-5	n D	4758.27	58.38	+3	4758.41
1	D	4765.91	1	D	4766.24	66.08	+3	4766.11
1	D	4772.67	2	nn D	4772.26	72.37	+3	4772.40
1	n D	4784.20	3	nn D	4784.07	84.14	+3	4784.17
1	n D	4789.44	2	n D	4789.36	89.40	+3	4789.43
1	n D	4815.90	2-3	n D	4815.63	15.77	+3	4815.81
1-2	n D	4823.94				23.88	+3	4823.91
1	n D	4827.78	1-2	n D	4827.77	27.78	+3	4827.81
1	n D	4832.78	2	n D	4832.17	32.48	+3	4832.51
			1	n D	4836.21	36.27	+3	4836.30
			1	n D	4839.27	39.33	+3	4839.36
			1	D	4843.40	43.46	+3	4843.49
1	n D	4855.44	2	nn D	4855.17	55.31	+3	4855.34
			1	n D	4859.37	59.43	+3	4859.46
1	n D	4868.45				68.39	+3	4868.42
1	n D	4881.60	3-4	n D	4881.71	81.66	+3	4881.69
			2	nn D	4900.72	00.78	+3	4900.81
1-2	n D	4921.76	1	nn D	4920.23	21.00	+3	4921.03
1	n D	4924.94				24.88	+3	4924.91

## 19 PISCUM = 273 SCHJELLERUP

Means of Four Plates

G 294			G 300			G 303			G 357			MEAN WAVE-LENGTH		
Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		t. m.			t. m.			t. m.			t. m.			t. m.
10	w D	5173.48	7	Head	68.48	1-2	wn D	73.48	2-3	n D	73.48	68.48	+3	5168.51
			7	D	73.73	1-2	n D	83.77				73.54	+3	5173.57
			2	wn B	87.36				1	B	87.19	83.74	+3	5183.77
						1	n D	88.89	1-2	n D	88.95	87.28	+3	5187.31
1	B	5190.94	4	B	91.49	1-2	n B	90.81				88.92	+3	5188.95
4	wn D	5192.69	3	D	93.34	2	D	92.77	4	n D	93.31	91.08	+3	5191.11
												93.03	+3	5193.06

## 19 PISCUM = 273 SCHJELLERUP—Continued

G 259			G 260			G 263			G 257			MEAN WAVE-LENGTH		
Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Uncor- rected for Velocity	Cor- for V	Corrected for Velocity
		t.m.			t.m.			t.m.			t.m.	t.m.		t.m.
2	n B	5196.92				1-2	n B	97.19	1	n B	97.60	97.07	+3	5197.10
1	B	5203.76	2	n B	04.22							03.99	+3	5204.02
				w D	08.54					w D	08.09	08.32	+3	5208.35
3	n B	5214.40	6	B	14.85	1 2	B	14.54				14.60	+3	5214.63
1	n D	5216.53	1-2	D	16.86	1	n D	16.78				16.72	+3	5216.75
3 4	n B	5218.82	5	n B	18.94	1	B	18.40				18.72	+3	5218.75
10	n D	5226.34	7	D	26.93	1	n D	25.55	6	n D	25.80	26.16	+3	5226.19
1	n B	5229.38	3-4	B	29.95							29.67	+3	5229.70
2	n D	5234.19	5	D	34.69	1-2	n D	34.04	3	n D	34.04	34.24	+3	5234.27
			1	D	40.47	1	D	39.70	1-2	n D	39.55	39.91	+3	5239.94
3 4	B	5245.23	2 3	B	45.80	1 2	n B	45.00				45.34	+3	5245.37
5	D	5247.32	6-7	D	47.89	3-4	n D	47.27	5	D	47.53	47.53	+3	5247.56
1 2	B	5249.28	4	B	49.83	1	n B	49.22				49.44	+3	5249.47
1 2	D	5251.46	5-6	D	51.84	3	n D	51.11	5 6	D	51.20	51.41	+3	5251.44
1	nn D	5255.67	1	D	56.28	1	D	55.81				55.92	+4	5255.96
6	wn D	5270.27	6	D	70.60	7	n D	70.20	4	D	70.62	70.42	+4	5270.46
2	n B	5279.43	3	B	80.13	2-3	n B	80.03	2	n B	79.60	79.55	+4	5279.59
1	n D	5283.79	1	D	83.87	1-2	D	82.29	2	n D	83.12	83.13	+4	5283.17
4	n D	5297.94	6	D	98.41	3	n D	98.41	5	n D	97.86	98.15	+4	5298.19
3	n D	5302.69	2	n D	02.52	1	n D	02.82	2	n D	02.64	02.72	+4	5302.76
4	n B	5305.00	4	B	05.01	1	B	05.80	1-2	n B	05.08	05.22	+4	5305.26
2	n B	5312.99	2	n B	13.33	2	n B	13.17	2	n B	13.21	13.18	+4	5313.22
1	n D	5314.69	1	n D	15.51	3	n D	15.44	3	n B	15.27	15.23	+4	5315.27
4	nn B	5318.12	6	B	18.00	4	n B	17.66	3	n B	17.72	17.87	+4	5317.91
			1-2	D	20.62	2	n D	20.95	2	n D	21.18	20.95	+4	5320.99
			1	D	25.63	1	n D	25.31	1	n D	25.18	25.28	+4	5325.32
10	w D	5329.03	6	n D	29.22	2 3	n D	28.76	2	n D	28.93	28.99	+4	5329.03
						1-2	B	39.45	1-2	n D	36.90	36.90	+4	5336.94
5 6	wn B	5339.11	3-4	B	39.59	1-2	B	39.45	2-3	n B	39.11	39.32	+4	5339.36
1	D	5341.15	2	D	41.50	4	D	41.17	2	n D	41.22	41.26	+4	5341.30
2	wn D	5350.19	3	wn D	50.12	3	D	50.08	4	n D	49.73	50.03	+4	5350.07
2	nn B	5352.64	2 3	B	52.92	2	wn B	52.70	1	n B	52.43	52.67	+4	5352.71
			1	D	62.95				1	D	62.69	62.95	+4	5362.99
			0 1	D	67.39	2	n D	66.69	1	n D	66.61	66.90	+4	5366.94
			2-3	B	68.89	2	B	68.59				68.74	+4	5368.78
8	wn D	5372.06	9	D	71.64	9	w D	71.69	8	D	71.25	71.66	+4	5371.70
6	n B	5374.98	8-9	B	75.40	5 6	n B	75.93	5	B	74.93	75.34	+4	5375.38
1	n D	5377.10	0-1	D	78.17	2	n D	77.60	2	D	77.32	77.54	+4	5377.58
			2-3	B	79.58	4	wn B	80.08	3	n B	79.77	79.78	+4	5379.82
			1	D	91.77	1	D	90.65	1	nn D	90.76	91.05	+4	5391.09
3	n D	5397.43	3	D	97.67	1	D	97.70	4	n D	97.35	97.54	+4	5397.58
2	n B	5403.70	2	B	04.33							03.90	+4	5403.94
0-1	n D	5406.19	1	n D	06.81	1-2	n D	06.49	1	n D	06.05	06.39	+4	5406.43
2 3	n B	5410.25	2	D	10.99	2 3	D	10.55	4	D	09.94	10.24	+4	5410.28
2-3	n B	5412.47	1	B	12.82	1	B	12.50				12.60	+4	5412.64
			4	D	15.01	1	D	14.01	1	n D	14.21	14.41	+4	5414.45
7-8	B	5417.38	6-7	wn B	17.49	7	wn B	16.98	6 7	n B	17.14	17.25	+4	5417.29
2 3	n D	5420.21	2 3	D	20.53	2	D	19.87	2-3	D	19.89	20.13	+4	5420.17
4	B	5423.16	5-6	B	23.53	4	n B	23.18	2-3	n B	22.90	23.19	+4	5423.23
			1	D	25.76	1	D	25.09	1	D	24.73	25.20	+4	5425.24
3	n B	5428.15	5	B	28.00	2-3	B	27.69				27.95	+4	5427.99
2	n D	5430.37	4	D	30.67	3	D	30.30	3	D	30.08	30.35	+4	5430.39
2	B	5432.21	3	B	32.61	2	B	32.21				32.34	+4	5432.38
			1	D	34.69	1	D	33.92	2	D	33.88	34.16	+4	5434.20
			0-1	D	39.00	1	n D	38.82	2	D	38.55	38.79	+4	5438.83
5 6	B	5445.51	5	B	45.40	1	B	45.07	2	n B	44.63	45.15	+4	5445.19
4	n D	5448.30	6	D	48.38	10	D	47.99	5 6	D	47.73	48.10	+4	5448.14
4	n B	5451.05	3	B	51.55	2	B	50.65	1-2	B	50.79	51.01	+4	5451.05
4 5	n B	5454.19	3	B	54.34	2-3	B	53.65	2	B	53.14	53.81	+4	5453.85
1	n D	5457.13	2-3	D	57.06	3-4	n D	56.79	4	D	56.71	56.92	+4	5456.96
2 3	n B	5459.19	1-2	B	59.49	1	B	58.97	1	B	58.73	59.10	+4	5459.14
			1	D	61.36	2	D	60.89	2	D	60.61	60.95	+4	5460.99
2	B	5462.84				1-2	n B	62.77	2	B	63.01	62.87	+4	5462.91
			4	B	63.72							63.72	+4	5463.76
2	B	5465.41							1 2	B	64.81	65.11	+4	5465.15
				w D	68.47	0 1	D	67.99	2	n D	66.90	67.79	+4	5467.83
3	n B	5471.99	2	B	72.78	3	n B	72.27	2	B	72.11	72.39	+4	5472.43
			1	D	74.82	1-2	n D	74.47	2	n D	74.28	74.52	+4	5474.56

19 TISCHUM 273 SCHJELLERUP *Continued*

G 25			G 26			G 28			G 29			MEAN WAVE-LENGTH		
Inten-	Char-	Wave-	Inten-	Char-	Wave-	Inten-	Char-	Wave-	Inten-	Char-	Wave-	Uncor-	Cor-	Corrected
sity	acter	Length	sity	acter	Length	sity	acter	Length	sity	acter	Length	rected for	for	for
		t.m.			t.m.			t.m.			t.m.	Velocity	V	Velocity
			1	D	78.10				1-2	n D	78.00	78.05	+	5478.09
			5	B	80.70	1	B	80.99				80.85	+	5480.89
2	D	5482.52	2	D	83.19	2	D	82.63	2-3	D	82.44	82.69	+	5482.73
2-3	n B	5495.77	1-2	B	96.47	2	n B	95.85				96.03	+	5496.07
2-3	n D	5498.52	4-5	D	98.54	4-5	D	98.13	3	D	97.71	98.23	+	5498.27
1	n D	5501.96	1-2	n D	02.02	1	D	02.12	2	D	02.01	02.03	+	5502.07
1	n D	5506.76	0-1	D	07.66	1	n D	06.92	1	D	07.23	07.14	+	5507.18
2	n B	5509.15	4	n B	09.18	1-2	B	09.89				09.17	+	5509.51
1	n B	5510.90				2-3	B	10.45				10.68	+	5510.72
			1	D	13.06	1-2	n D	12.57	1-2	n D	12.34	12.66	+	5512.70
			0-1	D	25.05	1	n D	24.16	1	n D	23.99	24.40	+	5521.44
1	D	5528.45	0-1	D	28.41				1-2	D	27.92	28.20	+	5528.24
			2	B	32.10	2	n B	31.83	1	n B	31.68	31.92	+	5531.96
			1	D	34.37	1-2	D	33.70	1	D	33.41	33.83	+	5533.87
2	n D	5539.86	8	n D	39.79	10	w D	39.46	7	n D	39.67	39.69	+	5539.73
			Head		41.75							41.75	+	5541.79
			6	B	43.84	2-3	n B	43.35				43.40	+	5543.44
1	n D	5547.95	1	D	48.75	1	n D	48.28	2	n D	48.20	48.30	+	5548.34
			1	D	52.50	1	n D	52.45	1	n D	52.19	52.38	+	5552.42
			2	B	54.55	2	B	54.01	3	B	54.06	54.25	+	5554.29
			1	D	56.64	1	D	56.25	1-2	D	55.96	56.28	+	5556.32
1	n D	5562.42	1-2	n D	62.81	1	D	62.85	2	D	62.28	62.51	+	5562.55
3	n B	5564.30	2-3	B	64.75	2	B	64.57	2	B	64.15	64.45	+	5564.49
1	D	5566.29	2-3	D	66.99	1-2	D	66.70	2	n D	66.27	66.56	+	5566.60
			1	D	70.67	1	D	69.91	1	D	70.17	70.25	+	5570.29
			0-1	D	74.21	1	D	73.20	1	D	73.17	73.53	+	5573.57
						1	B	74.75				74.75	+	5574.79
						1	D	76.45	1	D	76.07	76.46	+	5576.49
8	n D	5583.84	8-9	D	84.05	10	n D	83.91	8	D	83.95	83.94	+	5583.98
			Head		85.76							85.76	+	5585.80
3	B	5586.80	5	B	87.21	4-5	B	86.90	4	E	86.79	86.93	+	5586.97
			1	n D	89.28	1	n D	89.13	2	n D	88.56	89.02	+	5589.06
			1-2	n B	92.45	2	n B	92.07	1-2	B	92.18	92.23	+	5592.27
			1	n D	95.29	1	D	94.26	1-2	n D	93.86	94.47	+	5594.51
6	n B	5597.15	1	B	97.69	3-4	B	97.40	1-2	B	97.13	97.47	+	5597.51
			1	n D	99.97	1	n D	99.66	1	n D	99.05	99.56	+	5599.60
						1	B	06.36				06.36	+	5606.40
1	n D	5609.13	1-2	n D	09.55	1	n D	09.02	3	n D	09.48	09.17	+	5609.22
			0-1	D	15.87	0-1	D	15.60	1	n D	15.09	15.52	+	5615.56
2	n B	5617.04	2	B	17.64							17.34	+	5617.38
			1-2	n D	20.02	2-3	n D	19.97	3-4	n D	20.10	20.03	+	5620.07
						1	B	22.25				22.25	+	5622.29
2	n D	5624.00	2	n D	24.81	2	n D	24.74	4-5	n D	24.52	24.67	+	5624.71
			2	B	27.62	1	B	27.71				27.66	+	5627.70
			2-3	B	30.60	1-2	B	30.70				30.65	+	5630.69
8	n D	5634.21	10	D	34.00	10	D	34.46	10	D	33.92	34.17	+	5634.21
	Head	5635.96			36.05			36.36				36.39	+	5636.13
			6	B	37.49	3	B	37.48				37.69	+	5637.59
			6	B	41.06	2-3	B	41.26	1-2	B	41.01	41.08	+	5641.12
			1	D	43.69	1	n D	43.65	1	n D	44.75	44.03	+	5644.07
			3-4	n B	46.83	1	n B	47.11	1	n D	46.23	46.71	+	5646.75
			0-1	D	50.00	1	n D	49.76	1	D	49.77	49.84	+	5649.88
			5-6	B	53.37	1	B	53.42				53.40	+	5653.44
3-4	B	5655.18	5	B	54.74	1-2	B	55.02	2	E	55.29	55.06	+	5655.10
			1	D	59.01	1-2	D	58.73	3	n D	57.92	58.05	+	5658.69
4	n B	5673.49	2-3	B	73.92	3	B	73.94	3	B	73.35	73.72	+	5673.76
1	D	5676.64	1-2	D	76.35	1-2	n D	76.31	2-3	D	76.05	76.37	+	5676.41
			1	B	79.09	1	n B	79.39	1-2	B	79.02	79.17	+	5679.21
			1	B	84.48	1	n B	84.52	1	B	83.75	84.25	+	5684.29
			1	D	87.12	1-2	D	87.61	1	n D	86.66	87.07	+	5687.11
			4-5	B	93.67	3-4	B	93.98	4-5	n D	93.57	93.74	+	5693.78
			0-1	D	97.10	1	D	96.72	2	n D	96.49	96.77	+	5696.81
5	n B	5704.61	3	B	06.26	3	n B	05.62	3	B	05.13	05.37	+	5705.41
			1-2	D	08.26	1-2	D	08.55	2-3	D	07.81	08.17	+	5708.21
			2	D	10.77	1-2	B	10.83	1-2	B	10.30	10.41	+	5710.45
2	n B	5709.74	1	D	12.76	1	n D	13.35	1-2	D	12.57	12.90	+	5712.94
			1	B	14.36							14.96	+	5715.00
			3	B	16.82	5	n B	16.90	3	B	17.27	17.01	+	5717.05

## 19 PISCUM = 273 SCHJELLERUP—Continued

G 259			G 260			G 263			G 357			MEAN WAVE-LENGTH		
Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		t.m.			t.m.			t.m.			t.m.	t.m.		t.m.
6	B	5717.92	2	B	17.74	...	...	...	...	...	...	17.83	+4	5717.87
...	...	...	1	n D	22.01	1	n D	20.95	2	D	21.12	21.36	+	5721.40
8	n B	5724.00	4-5	n B	24.31	2-3	B	24.13	2	B	23.80	24.08	+	5724.12
1	D	5730.46	3	n D	31.76	3	n D	31.40	1-2	n D	31.44	31.16	+	5731.20
...	...	...	2	n D	44.34	1	n D	44.75	3	n D	43.85	44.31	+	5744.35
...	...	...	1	n B	46.95	1	n B	47.15	...	...	...	47.05	+	5747.09
...	...	...	1	n D	49.08	1	n D	50.02	...	...	...	49.55	+	5749.59
...	...	...	3	n B	56.89	2-3	n B	57.06	...	...	...	56.98	+	5757.02
...	...	...	3	n D	62.80	1	n D	62.59	2-3	n D	62.79	62.70	+	5762.74
...	...	...	2-3	n B	66.90	1-2	n B	67.60	...	...	...	67.25	+	5767.29
...	...	...	2-3	n D	71.27	1	n D	70.73	1	n D	71.44	71.15	+	5771.19
...	...	...	1-2	n B	75.49	1-2	n B	76.08	1	B	75.74	75.77	+	5775.81
...	...	...	1	n D	77.76	1	n D	77.79	1	D	77.78	77.78	+	5777.82
...	...	...	1-2	B	80.18	1-2	n B	79.73	1	B	79.55	79.82	+	5779.86
...	...	...	3	n D	85.13	1	n D	85.92	...	...	...	85.53	+	5785.57
...	...	...	1-2	D	98.66	1	n D	98.61	1-2	D	98.16	98.64	+	5798.68
...	...	...	1	n D	22.69	...	...	...	1	D	22.69	22.69	+	5822.73

## 280 SCHJELLERUP

PLATE G 346 1899, October 18, G.M.T. 16h1. Hour angle, W 1h5 Star fair; comparison good						PLATE G 367 1899, December 29, G.M.T. 11h2. Hour angle, W 4h Star fair; comparison good						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
3	nn D	49.1115	4434.67	+ 9	4434.76		nn D	62.2999	4429.56	-34	4429.22	29.14	+37	4429.51
												34.85	+37	4435.22
							nn D	62.0955	4436.12	-35	4435.77	35.69	+37	4436.06
						B	from	62.0720	4436.88	-35	4436.5	36.4	37	4437.0
							to	61.9785	4439.92	-36	4439.56	39.48	+37	4439.9
	nn B	49.9832	4463.24	+ 5	4463.29							63.38	+38	4463.76
						4	wn D	61.1895	4466.08	-42	4465.66	65.58	+38	4465.96
	nn D	50.5099	4481.06	+ 2	4481.08	1	n D	61.0215	4471.77	-43	4471.34	71.26	+38	4471.64
1	n D	50.7400	4488.98	+ 1	4488.99	1	n D	60.7203	4482.09	-45	4481.64	81.36	+38	4481.74
	nn D	50.9450	4496.11	0	4496.11	1	n D	60.5093	4489.41	-47	4488.94	88.97	+38	4489.35
	nn D	51.0778	4500.76	- 1	4500.75		wn D	60.2908	4497.07	-48	4496.59	96.35	+38	4496.73
2	D	51.2257	4505.98	- 2	4505.96	2	n D	60.0242	4506.51	-48	4506.03	00.84	+38	4501.22
	nn D	51.4054	4512.36	- 3	4512.33	3	nn D	59.8414	4513.06	-49	4512.57	06.00	+38	4506.38
1-2	nn D	51.5497	4517.53	- 4	4517.49	2	n D	59.6899	4518.53	-49	4518.04	12.45	+38	4512.83
1-2	nn B	51.6385	4520.73	- 5	4520.68							17.77	+38	4518.15
	nn D	51.6825	4522.32	- 5	4522.27	1	n D	59.5592	4523.28	-49	4522.79	20.77	+38	4521.15
1	n B	51.7274	4523.94	- 5	4523.89							22.53	+38	4522.91
	w D	51.8039	4526.73	- 5	4526.68	1-2	n D	59.4587	4526.96	-49	4526.47	24.98	+38	4525.36
						D	from	59.352	4530.88	-49	4530.39	26.58	+38	4526.96
	wn D	52.0274	4534.89	- 6	4534.83		to	59.213	4536.01	-49	4535.52	30.31	+38	4530.7
												34.42	+38	4535.30
	w B	52.1002	4537.58	- 7	4537.51							35.44	+38	4535.8
1	n D	52.1520	4539.49	- 7	4539.42							37.60	+38	4537.98
	w D	52.5197	4553.21	- 9	4553.12	9	w D	58.7390	4553.76	-49	4553.27	39.51	+38	4539.89
B	from	52.569	4555.08	9	4555.0							53.20	+38	4553.58
	to	52.669	4558.86	- 9	4558.8							55.09	+38	4555.5
												58.89	+38	4559.3
1	D	52.7667	4562.56	-10	4562.46		nn D	58.5085	4560.29	-48	4559.81	59.73	+38	4560.11
0-1	D	52.8267	4564.85	-10	4564.75							62.55	+38	4562.93
	from	52.844	4565.52	-10	4565.4							64.84	+38	4565.22
B	to	52.937	4569.09	-10	4569.0							65.48	+38	4565.9
	nn D	52.9930	4571.41	-10	4571.31		nn D	58.2020	4571.53	47	4571.06	69.08	+38	4569.5
							nn D	58.1352	4577.06	-16	4576.60	71.15	+38	4571.53
												76.52	+38	4576.90

## 280 SCHJELLERUP—Continued

PLATE G 385						PLATE G 387						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Intensity	Character	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
			Å.		m.			mm.	Å.		Å.	Å.		Å.
5.6	n B	53.3020	4583.22	-10	4583.12	2	n D	57.8917	4586.64	-45	4586.19	83.21	+38	4583.59
2	n D	53.3707	4585.91	-10	4585.81							86.00	-38	4586.38
1	n D	53.5710	4593.82	-10	4593.72							93.81	-38	4594.19
2	n B	53.6198	4595.74	-10	4595.64							95.73	-38	4596.11
1	n B	53.7070	4599.21	-10	4599.11							99.20	-38	4599.58
7	D	53.8745	4605.92	9	4605.83	8	D	57.3968	4606.35	-42	4605.93	05.88	-38	4606.26
						B	from	57.3680	4607.64	-42	4607.22	07.14	-38	4607.5
3	n B	53.9284	4608.09	-9	4608.00							08.09	-38	4608.47
1	n D	54.1182	4615.79	-8	4615.71	to	nn D	57.1620	4616.06	-41	4615.65	15.08	-38	4616.06
4	n B	54.1567	4617.35	-8	4617.27							17.36	-38	4617.74
1	n D	54.1922	4618.80	-8	4618.72							18.91	-38	4619.29
	nn D	54.4330	4628.72	-6	4628.66							28.75	-38	4629.13
	n B	54.4779	4630.56	-6	4630.50							30.55	-38	4630.97
4	n B	54.6472	4637.61	-5	4637.56							37.65	-38	4638.03
3	D	54.6947	4639.60	-5	4639.55							39.48	-38	4639.86
												40.25	-38	4640.6
						B	to	56.5715	4640.69	-36	4640.33	41.72	-38	4642.10
1-2	n B	54.7444	4641.68	-5	4641.63	to		56.4825	4644.47	-35	4644.12	44.04	-38	4644.4
3	D	54.8347	4645.49	-4	4645.45	5	n D	56.4412	4646.23	-35	4645.88	45.67	-38	4646.05
												54.86	-39	4655.25
												57.10	-39	4657.5
2-3	n B	55.1780	4660.01	-1	4660.00	B	to	56.0695	4662.23	-31	4661.92	61.84	-39	4660.48
												63.53	-39	4662.2
1	D	55.2574	4663.41	0	4663.44							64.82	-39	4663.92
1	n B	55.2852	4664.73	0	4664.73							67.76	-39	4665.21
4	D	55.3472	4667.41	+1	4667.42							68.35	-39	4668.15
2	D	55.5047	4674.27	+3	4674.30		nn D	55.9283	4668.39	-29	4668.10	71.40	-39	4674.79
	wn D	55.6657	4681.78	+5	4681.83		nn D	55.6204	4674.78	-28	4674.50	81.77	-39	4682.16
	n B	56.3944	4714.06	+17	4714.23	5	wn D	54.9117	4714.14	-18	4713.96	11.10	-39	4718.49
	nn D	56.6945	4727.92	+22	4728.14		nn D	54.9045	4728.47	-17	4728.30	33.10	-39	4729.61
												37.24	-39	4733.5
						D	to	54.5010	4733.35	-17	4733.18	38.71	-39	4737.6
4	n B	56.9179	4738.38	+24	4738.62							40.76	-39	4741.2
						B	to	54.3400	4741.07	-16	4740.91	43.01	-39	4743.40
10	Head	57.0889	4742.67	+25	4742.92	D	from	54.3385	4741.07	-16	4740.91	44.89	-39	4745.28
	n B	57.0499	4744.62	+25	4744.87		Head	54.2550	4745.06	-15	4744.91	46.60	-39	4746.99
		57.0845	4746.26	+25	4746.51							48.44	-40	4748.8
						B	to	54.1801	4748.06	-14	4747.92	50.23	-40	4750.63
	wn B	57.2724	4755.23	+27	4755.50		nn D	54.1129	4750.45	-13	4750.31	55.31	-40	4755.71
5	n D	57.3385	4758.41	+27	4758.68		w B	54.0438	4755.25	-13	4755.12	58.59	-40	4758.99
1	n D	57.4955	4766.01	+28	4766.29		n D	53.9742	4758.63	-13	4758.50	66.38	-40	4768.78
	nn B	57.5534	4767.94	+28	4768.22							68.31	-40	4768.71
	nn D	57.8469	4783.22	+30	4783.52		wn D	53.4997	4782.05	-10	4781.95	82.74	-40	4784.14
							nn D	53.0218	4806.12	-9	4806.03	05.95	-40	4806.45
	nn B	58.4624	4812.73	+31	4813.04							13.13	-40	4813.53
2	n D	58.4624	4814.64	+31	4814.95							15.04	-40	4815.44
	nn B	58.5190	4817.18	+31	4817.49		nn B	52.7805	4818.30	-8	4818.22	17.86	-40	4818.26
							nn D	52.7088	4822.51	-8	4822.43	22.35	-40	4822.75
												26.12	-40	4826.52
	nn D	58.7082	4831.66	+30	4831.96	1	n D	52.6368	4826.28	-8	4826.20	32.69	-40	4832.19
						2	nn D	52.5227	4832.30	-8	4832.22	39.38	-40	4838.78
							nn B	52.3259	4839.54	-8	4839.46	57.01	-41	4857.42
9	B	59.3431	4860.61	+27	4860.88							60.97	-41	4861.38
		59.3192	4859.29	+27	4859.56							70.65	-41	4869.1
3	D	59.3710	4862.08	+27	4862.35							62.44	-41	4862.9
		59.4012	4863.88	+27	4864.15							64.70	-41	4865.11
							nn D	51.9000	4865.34	-10	4865.24	71.86	-41	4874.27
							nn D	51.7328	4875.05	-11	4874.94	76.21	-41	4876.6
							from	51.7085	4876.40	-11	4876.29	80.07	-41	4880.5
						B	to	51.6300	4880.26	-11	4880.15	81.64	-41	4884.53
						Max	B	51.6740	4878.31	-11	4878.20	81.64	-41	4884.53
							nn D	51.6105	4881.85	-11	4881.74	80.62	-41	4890.03
							nn D	51.4684	4889.82	-12	4889.70	85.24	-41	4895.7
							from	51.3685	4895.45	-12	4895.32	89.34	-41	4899.8
						B	to	51.2669	4899.56	-11	4899.42			

## 280 SCHJELLERUP—Continued

PLATE G 346						PLATE G 367						MEAN WAVE-LENGTH		
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
...	...	...	...	...	...	Max	B	51.3245	4897.94	-13	4897.81	97.73	+41	4898.14
...	...	...	...	...	...	1 2	nn D	51.2795	4900.51	-14	4900.37	00.29	+41	4900.70
...	...	...	...	...	...	...	nn D	50.9320	4920.49	-17	4920.32	20.24	+41	4920.65

## 280 SCHJELLERUP

PLATE G 396						PLATE G 350						MEAN WAVE-LENGTH		
1899, December 28, G.M.T. 11:06. Hour angle, W 55°. Star fair; comparison good						1900, January 2, G.M.T. 11:41. Hour angle, W 55°. Star fair; comparison good								
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
Spectrum	begins	40.9180	5170.70	-43	5170.27	...	...	48.7620	5168.48	-29	5168.19	69.23	+42	5169.7
...	nn D	41.2347	5183.60	-43	5183.17	...	nn D	48.9115	5174.48	-33	5174.15	73.92	+43	5174.35
3	n D	41.4822	5193.76	-43	5193.33	2	n D	49.3884	5193.87	-45	5193.42	83.45	+43	5193.88
D	from	41.7300	5204.03	-45	5203.58	...	w D	49.7854	5210.28	-51	5209.77	93.38	+43	5193.81
...	to	41.9395	5212.78	-47	5212.31	...	...	...	...	...	...	03.81	+43	5204.3
...	wn D	42.2515	5225.95	-49	5225.46	8	w D	50.1743	5226.06	-55	5226.06	09.54	+43	5209.97
...	...	...	...	...	...	B	from	50.2250	5228.75	-56	5228.19	12.54	+43	5213.0
...	...	...	...	...	...	...	to	50.4380	5246.40	-57	5245.83	25.76	+43	5226.19
...	nn D	42.7508	5247.38	-51	5246.87	2	n D	50.3650	5234.70	-57	5234.13	45.60	+43	5246.0
5	n D	42.8324	5250.92	-51	5250.41	1	n D	50.6702	5247.78	-56	5247.22	33.90	+43	5234.33
2-3	n D	43.2787	5270.48	-49	5269.99	4	n D	50.7688	5252.04	-56	5251.48	47.05	+43	5247.48
2	n D	43.5644	5283.19	-48	5282.71	...	nn D	51.2009	5270.91	-54	5270.37	50.95	+43	5251.4
1	n D	43.8934	5298.01	-45	5297.56	...	nn D	51.4825	5283.38	-50	5282.88	70.18	+44	5270.62
...	nn D	43.9923	5302.50	-45	5302.05	...	nn D	51.8159	5298.33	-45	5297.88	82.80	+44	5283.24
...	nn D	44.1069	5307.73	-43	5307.30	...	...	...	...	...	...	97.72	+44	5298.16
...	nn D	44.2964	5315.05	-41	5314.64	...	...	...	...	...	...	02.28	+44	5302.72
...	nn D	44.3880	5320.68	-40	5320.28	...	...	...	...	...	...	07.53	+44	5307.97
...	wn D	44.5779	5329.48	-36	5329.12	...	w D	52.5064	5329.94	-35	5329.59	14.87	+44	5315.31
...	nn D	44.7330	5336.73	-35	5336.38	...	...	...	...	...	...	20.51	+44	5320.95
4	D	45.0102	5349.81	-30	5349.51	1	n D	52.7540	5341.49	-32	5341.17	29.36	+44	5329.80
...	...	...	...	...	...	3	n D	52.9510	5350.76	-29	5350.47	36.61	+44	5337.05
...	...	...	...	...	...	2	B	53.0073	5353.43	-28	5353.15	41.40	+44	5341.84
10	w D	45.4645	5371.56	-25	5371.31	Con. x from	...	53.0430	5355.12	-28	5354.81	49.99	+44	5350.43
2	B	45.5302	5374.74	-25	5374.49	8	D	53.3530	5369.93	-24	5369.69	52.92	+45	5353.37
...	nn D	45.5707	5376.71	-24	5376.47	3	B	53.3993	5372.15	-23	5371.92	54.61	+45	5355.1
B	from	45.5880	5377.55	-24	5377.31	...	n D	53.4640	5375.27	-22	5375.05	69.46	+44	5369.9
...	to	45.0610	5381.11	-23	5380.88	Max	B	53.5632	5380.07	-21	5379.86	77.03	+45	5377.48
Con. y	from	45.7350	5384.71	-22	5384.49	...	...	...	...	...	...	77.54	+45	5378.0
Sec. y	to	45.8425	5389.88	-22	5389.76	...	...	...	...	...	...	80.09	+45	5380.54
6	nn D	45.9650	5391.09	-21	5390.88	...	nn D	53.7980	5391.52	-19	5391.33	81.11	+45	5381.6
...	D	45.9830	5396.91	-21	5396.70	4	n D	53.9200	5397.51	-17	5397.34	84.72	+45	5385.2
...	...	46.1617	5405.77	-19	5405.58	...	from	53.9680	5399.88	-17	5399.71	89.99	+45	5390.4
...	...	...	...	...	...	B	to	54.0840	5405.61	-16	5405.45	91.11	+45	5391.56
3	D	46.2497	5410.16	-18	5409.98	1	to	54.1377	5408.27	-15	5408.12	97.02	+45	5397.47
B	from	46.2850	5412.42	-18	5412.24	...	nn D	54.1800	5410.37	-15	5410.22	99.48	+45	5399.9
...	to	46.4160	5418.49	-17	5418.31	...	from	54.2520	5413.97	-14	5413.83	05.81	+45	5406.26
2-3	D	46.4445	5419.92	-17	5419.75	...	to	54.3540	5419.07	-13	5418.94	05.22	+45	5405.7
...	...	...	...	...	...	Max	...	54.3223	5417.48	-13	5417.35	07.89	+45	5408.33
...	...	...	...	...	...	...	nn D	54.3795	5420.34	-12	5420.22	10.10	+45	5410.55



## 290 SCHJELLERUP—Continued

PLATE G 286						PLATE G 290						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	μm.		μm.			mm.	μm.		μm.	μm.		μm.
2	n B	51.7968	5724.11	-46	5723.65	Max	B	59.7514	5724.68	-41	5724.27	23.96	+48	5724.44
...	nn D	51.9112	5731.46	-47	5730.99	...	...	...	...	...	...	31.22	+48	5731.70
...	...	...	...	...	...	1-2	n D	59.8747	5732.60	-42	5732.18	31.95	+48	5732.43
...	...	...	...	...	...	B	from	59.9020	5734.40	-42	5733.98	33.75	+48	5734.2
...	...	...	...	...	...	...	to	60.0390	5743.30	-43	5742.87	42.64	+48	5743.1
...	nn D	52.1065	5744.10	-49	5743.61	...	...	...	...	...	...	43.84	+48	5744.32
...	nn D	52.2212	5751.60	-50	5751.10	1	n D	60.1725	5751.89	-44	5751.45	51.22	+48	5751.70
2-3	wn B	52.3143	5757.70	-50	5757.20	...	w B	60.2697	5758.25	-45	5757.80	57.57	+48	5758.05
...	wn D	52.4020	5763.48	-50	5762.98	...	...	...	...	...	...	63.21	+48	5763.69
...	...	...	...	...	...	2	n B	60.4330	5769.00	-46	5768.54	68.31	+48	5768.79
1	n D	52.5380	5772.49	-50	5771.99	...	n D	60.4740	5771.71	-46	5771.25	71.62	+48	5772.10
...	...	...	...	...	...	2	n B	60.6135	5780.98	-46	5780.52	80.29	+48	5780.77
...	...	...	...	...	...	End	...	61.9530	5783.40	-50	5782.90	72.67	+48	5783.7

## 318 BIRMINGHAM = DM.68 617

PLATE G 296						PLATE G 298						MEAN WAVE-LENGTH		
1899, January 15, G.M.T. 1941. Hour angle, E 44° Star good; comparison fair						1900, March 31, G.M.T. 180 ±. Hour angle, W 2° Star excellent; comparison good								
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	μm.		μm.			mm.	μm.		μm.	μm.		μm.
...	nn D	64.0863	4389.68	+9	4389.77	...	nn D	56.1006	4390.45	-47	4389.98	80.88	+15	4390.03
...	nn D	63.7893	4395.06	+8	4395.14	...	nn D	56.4269	4395.37	-48	4394.89	95.02	+15	4395.17
...	nn D	63.4673	4400.94	+7	4401.01	...	nn D	56.7340	4401.10	-50	4400.60	00.87	+15	4401.02
2	n B	63.3981	4402.21	+6	4402.27	5	n B	56.8282	4402.86	-50	4402.36	02.32	+15	4402.47
2-3	nn D	63.2537	4404.86	+5	4404.91	...	wn D	56.9736	4405.59	-51	4405.08	05.00	+15	4405.15
...	wn D	63.0670	4408.30	+4	4408.34	...	...	...	...	...	...	08.37	+15	4408.52
...	...	...	...	...	...	B	from	57.2130	4410.10	-52	4409.58	09.55	+15	4409.70
...	...	...	...	...	...	...	to	57.4510	4414.60	-53	4414.07	14.04	+15	4414.2
2-3	n D	62.7075	4415.01	+3	4415.04	...	nn D	57.4915	4415.41	-53	4414.88	14.96	+15	4415.11
2	n D	62.1355	4425.81	+1	4425.82	1	n D	58.0494	4426.15	-55	4425.60	25.71	+15	4425.86
3	n D	62.0466	4427.50	0	4427.50	2	n D	58.1354	4428.66	-55	4428.11	27.81	+15	4427.96
...	nn D	61.9070	4430.16	0	4430.16	1-2	n D	58.2797	4430.63	-55	4430.08	30.12	+15	4430.27
...	...	...	...	...	...	...	from	58.3200	4431.40	-56	4430.84	30.81	+15	4431.0
...	...	...	...	...	...	B	to	58.4530	4434.00	-56	4433.44	35.41	+15	4433.6
...	...	...	...	...	...	Max	B	58.3050	4432.29	-56	4431.73	37.70	+15	4431.85
1	n D	61.7190	4433.80	-1	4433.79	...	nn D	58.4726	4434.40	-56	4433.84	33.81	+15	4433.96
...	wn D	61.6256	4435.57	-1	4435.56	5	nn D	58.5374	4435.67	-56	4435.04	35.34	+15	4435.49
2	n D	61.4923	4438.15	-2	4438.13	1	nn D	58.6850	4438.58	-56	4438.02	38.08	+15	4438.23
...	B	61.4420	4439.10	-2	4439.08	5-6	n B	58.7336	4439.54	-56	4438.98	38.95	+15	4439.10
1 2	D	61.1761	4444.30	-3	4444.27	...	...	...	...	...	...	44.30	+15	4444.45
...	...	...	...	...	...	B	from	59.0300	4445.43	-57	4444.86	44.83	+15	4445.0
...	...	...	...	...	...	...	to	59.1260	4447.30	-57	4446.73	46.70	+15	4446.9
...	wn D	61.0220	4447.31	-4	4447.27	2	n D	59.1557	4447.94	-57	4447.37	47.32	+15	4447.47
2	n B	60.9604	4448.52	-4	4448.48	6	n B	59.2065	4449.01	-57	4448.44	48.46	+15	4448.61
...	wn D	60.8905	4449.90	-4	4449.86	...	wn D	59.2829	4450.49	-57	4449.92	49.89	+15	4450.04
2	n D	60.7160	4453.34	-5	4453.29	1	n D	59.4432	4453.71	-58	4453.13	53.21	+15	4453.36
...	nn D	60.6218	4455.21	-5	4455.16	1	n D	59.5472	4455.81	-58	4455.23	55.20	+15	4455.35
...	nn D	60.3790	4460.00	-6	4459.94	...	...	...	...	...	...	59.97	+15	4460.12
...	wn D	60.2858	4461.91	-6	4461.85	3	n D	59.8792	4462.56	-58	4461.98	61.92	+15	4462.07
4	n B	60.1904	4463.82	-7	4463.75	...	wn B	59.9664	4464.34	-58	4463.76	63.76	+15	4463.91
...	...	...	...	...	...	1	n D	60.0417	4465.89	-58	4465.31	65.28	+15	4465.43
1	nn D	59.8040	4471.62	-8	4471.54	...	from	60.3810	4472.90	-58	4472.32	72.29	+15	4472.4
...	...	...	...	...	...	B	to	60.4880	4474.90	-57	4471.33	74.30	+15	4474.5
1	n D	59.5902	4475.98	-8	4475.90	...	...	...	...	...	...	75.93	+15	4476.08

## 318 BIRMINGHAM—Continued

PLATE G 256						PLATE G 268						MEAN WAVE-LENGTH		
Inter-	Char-	Mean	Wave-	Cor.	Wave-	Inter-	Char-	Mean	Wave-	Cor.	Wave-	Uncor-	Cor.	Corrected
ference	acter	Scale	Length by	from	Length	ference	acter	Scale	Length by	from	Length	rected for	for	for
		Reading	Formula	Curve	t.m.			Reading	Formula	Curve	t.m.	Velocity	V	Velocity
2 3	nn D	59.2813	4482.32	-9	4482.23	1	nn D	60.7596	4480.77	-57	4480.20	80.27	+15	4480.42
						2	nn D	60.8585	4482.85	-57	4482.28	82.26	+15	4482.41
						2	n B	60.9177	4484.06	-57	4483.52	83.49	+15	4483.64
						1 2	n B	61.0422	4486.71	-56	4486.15	86.12	+15	4486.27
	nn D	59.0411	4487.28	-9	4487.19	2	nn D	61.0989	4487.91	-56	4487.35	87.27	+15	4487.42
3	n D	58.9247	4489.70	-10	4489.60	3	n D	61.2096	4490.26	-56	4489.70	89.65	+15	4489.80
	nn D	58.5813	4496.89	-10	4496.79		wn D	61.5444	4497.40	-55	4496.85	96.82	-15	4496.97
2 3	nn D	58.3523	4501.73	-10	4501.63		nn D	61.7749	4502.35	-54	4501.81	01.72	-15	4501.87
	from	58.3210	4502.40	-10	4502.30		from	61.8000	4503.00	-54	4502.46	02.38	-15	4502.5
B	to	58.1400	4506.20	-10	4506.10	B	to	61.9770	4506.70	-53	4506.17	06.14	-15	4506.3
Max	B	58.2340	4504.20	-10	4504.10							04.13	-15	4504.3
2	n D	58.1063	4506.96	-10	4506.86	3	n D	62.0142	4507.53	-53	4507.00	06.93	-15	4507.08
						6	n B	62.0837	4509.05	-53	4508.52	08.49	-15	4508.64
1	nn D	57.9785	4509.10	-9	4509.01	1	n D	62.1424	4510.32	-52	4509.80	09.41	-15	4509.96
						2	nn D	62.2669	4513.05	-51	4512.52	12.49	-15	4512.64
4	wn D	57.5856	4518.15	-8	4518.07	2	n D	62.5267	4518.75	-50	4518.25	18.16	-15	4518.31
						3	wn B	62.6753	4522.04	-49	4521.55	21.52	-15	4521.67
5	nn D	57.3650	4522.94	-8	4522.86	4	n D	62.7391	4523.45	-49	4522.96	22.91	-15	4523.06
	nn D	57.1090	4528.54	-7	4528.47							28.50	-15	4528.65
1	nn D	56.9826	4531.32	-6	4531.26		nn D	63.1029	4531.57	-47	4531.10	31.18	-15	4531.43
	nn D	56.7810	4535.78	-6	4535.72		nn D	63.3047	4536.11	-46	4535.65	35.69	-15	4535.84
							from	63.3420	4536.90	-46	4536.44	36.41	-15	4536.6
3	wn B	56.7118	4537.25	-5	4537.20	B						37.23	-15	4537.38
2	n B	56.6471	4538.76	-5	4538.71							38.74	-15	4538.89
							to	63.4790	4540.00	-45	4539.55	39.52	-15	4539.7
	nn D	56.5568	4540.46	-5	4540.41	4	n D	63.5097	4540.76	-45	4540.31	40.36	-15	4540.51
	nn D	56.3491	4545.43	-3	4545.40		wn D	63.7440	4546.10	-44	4545.66	45.53	-15	4545.68
1	nn D	56.2963	4546.61	-3	4546.58							46.61	-15	4546.76
						4	n B	63.8277	4548.02	-43	4547.59	47.56	-15	4547.71
	nn D	56.1758	4549.33	-2	4549.31		nn D	63.8949	4549.56	-43	4549.13	49.22	-15	4549.37
	from	56.0490	4552.20	-1	4552.19		from	64.0240	4552.54	-41	4552.13	52.16	-15	4552.3
D	to	55.9160	4555.20	0	4555.20	D	to	64.1530	4555.50	-41	4555.09	55.15	-15	4555.3
Max	D	55.9955	4553.41	-1	4553.40							53.43	-15	4553.58
	from	55.9160	4555.20	0	4555.20		from	64.1530	4555.50	-41	4555.09	55.15	-15	4555.3
B	to	55.7430	4559.20	+1	4559.21	B	to	64.3290	4559.60	-39	4559.21	59.21	-15	4559.4
	nn D	55.6930	4560.30	-1	4560.31	1	nn D	64.2470	4557.70	-40	4557.30	57.27	-15	4557.42
4	nn D	55.5614	4563.34	-2	4563.36	5	nn D	64.3721	4560.61	-39	4560.22	60.27	-15	4560.42
2	nn D	55.4598	4565.68	-2	4565.70	2	n D	64.5082	4563.79	-38	4563.41	63.39	-15	4563.54
	from	55.4400	4566.10	-3	4566.13	1	n D	64.5831	4565.79	-37	4565.42	65.56	-15	4565.71
B	to	55.2430	4570.70	+4	4570.74	B	from	64.6160	4566.30	-37	4565.93	66.03	-15	4566.2
	from	55.2430	4570.70	+4	4570.74		to	64.7900	4570.40	-36	4570.04	70.39	-15	4570.5
D												70.77	-15	4570.9
	to	54.9870	4576.50	+5	4576.75		wn D	64.8579	4572.02	-35	4571.67	71.64	-15	4571.79
							nn D	64.9976	4575.33	-35	4574.98	74.95	-15	4575.10
1	nn D	54.9575	4577.37	+6	4577.43							76.78	-15	4576.9
1	nn D	54.8243	4580.50	+7	4580.57		nn D	65.0607	4577.55	-34	4577.21	77.32	-15	4577.47
							nn D	65.2140	4580.50	-33	4580.17	80.37	-15	4580.52
						1	nn D	65.3089	4582.77	-32	4582.45	82.42	-15	4582.57
						1	n D	65.4024	4585.01	-31	4584.70	84.67	-15	4584.82
						1	nn D	65.4560	4586.30	-31	4585.99	85.96	-15	4586.1
1	nn D	54.2843	4590.94	-9	4591.03	1 2	nn D	65.6086	4591.45	-29	4591.16	91.10	-15	4591.25
2	nn D	54.2548	4594.02	+10	4594.12							94.15	-15	4594.30
						5	n B	65.8061	4596.26	-28	4595.98	95.95	-15	4596.10
						2	n D	65.9276	4597.76	-27	4597.49	97.46	-15	4597.61
3	nn D	53.9766	4600.71	+11	4600.82	3	n D	66.0637	4600.36	-26	4600.10	00.46	-15	4600.61
	from	53.7540	4605.10	+12	4605.52							05.55	-15	4605.7
D	to	53.6790	4608.00	+13	4608.13							08.16	-15	4608.3
10	nn D	53.7443	4609.59	+12	4609.71	10	D	66.2012	4606.95	-25	4606.70	06.71	-15	4606.86
	from	53.6790	4608.00	+13	4608.13							08.16	-15	4608.3
						2	n B	66.3959	4609.31	-24	4609.07	09.04	-15	4609.19
						1	nn D	66.4517	4610.69	-24	4610.45	10.42	-15	4610.57
						1	n B	66.5241	4612.50	-23	4612.27	12.24	-15	4612.39
2	n D	53.4600	4612.80	+13	4612.93							12.96	-15	4613.1
		53.4613	4613.27	+14	4613.41	2 3	nn D	66.5834	4613.97	-22	4613.75	13.58	-15	4613.73

## 318 BIRMINGHAM—Continued

PLATE G 276						PLATE G 283						MEAN WAVE-LENGTH		
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.			t.m.
5	n B	53.3983	4614.81	+14	4614.95	6	n B	66.6355	4615.28	+22	4615.06	15.00	+15	4615.15
3-4	n D	53.3478	4616.06	+14	4616.20	4	n D	66.6885	4616.63	+22	4616.41	16.31	+15	4616.46
8	n B	53.2801	4617.73	+14	4617.87	7	n B	66.7479	4618.09	+21	4617.88	17.88	+15	4618.03
6	n D	53.2061	4619.56	+15	4619.71	6	n D	66.8206	4619.92	+21	4619.71	19.71	+15	4619.86
5	n B	53.1385	4621.23	+15	4621.38							21.41	+15	4621.56
2-3	nn D	53.0779	4622.74	+15	4622.89	2	nn D	66.9471	4623.11	+20	4622.91	22.90	+15	4623.05
						8	n D	67.2030	4629.60	+18	4629.42	29.39	+15	4629.54
						2	n B	67.2736	4631.40	+18	4631.22	31.19	+15	4631.34
3	n B	52.4395	4638.77	+18	4638.95	3-4	n B	67.5707	4639.28	+16	4639.12	39.04	+15	4639.19
6	D	52.3870	4640.10	+18	4640.28	6	n D	67.6277	4640.49	+16	4640.33	40.31	+15	4640.46
												41.18	+15	4641.3
4	wn B	52.3214	4641.77	+18	4641.95	B	from	67.6610	4641.36	+15	4641.21	42.01	+15	4642.16
Complete absorption							to	67.7680	4644.10	+14	4643.96	43.93	+15	4644.1
10	w D	48.8333	4735.84	+27	4736.11	D	from	71.0540	4734.12	+4	4734.16	34.13	+16	4734.3
							to	71.1830	4737.80	+4	4737.84	36.14	+16	4736.30
5-6	n B	48.7468	4738.31	+27	4738.58	B	from	71.1830	4737.80	+4	4737.84	37.81	+16	4738.0
1	n D	48.6991	4739.68	+27	4739.95	4 n B		71.2102	4738.64	+4	4738.68	38.63	+16	4738.79
												39.98	+16	4740.14
10	D	48.5694	4743.41	+27	4743.68		to	71.3100	4741.50	+4	4741.54	41.51	+16	4741.7
						10	w D	71.3881	4743.83	+5	4743.88	43.78	+16	4743.94
						10	from	71.3100	4741.50	+4	4741.54	41.51	+16	4741.7
						10	to	71.4440	4745.40	+5	4745.45	45.42	+16	4745.6
Head		48.5081	4745.18	+27	4745.45	Head		71.4469	4745.55	+5	4745.60	45.53	+16	4745.69
4	n B	48.4736	4746.17	+27	4746.44		w B	71.4866	4746.72	+6	4746.78	46.61	+16	4746.77
	nn D	48.3766	4748.98	+27	4749.25		nn D	71.5777	4749.39	+6	4749.45	49.34	+16	4749.50
	nn D	48.0661	4758.04	+27	4758.31	4	n D	71.8869	4758.54	+7	4758.61	58.46	+16	4758.62
	nn D	47.7955	4766.01	+27	4766.28							66.31	+16	4766.47
	nn D	47.5756	4772.54	+27	4772.81	2-3	nn D	72.3619	4772.79	+9	4772.88	72.85	+16	4773.01
						2	n B	73.5757	4810.30	+12	4810.42	10.39	+16	4810.54
	nn D	46.2956	4811.58	+26	4811.84							11.87	+16	4812.03
3	n D	46.1761	4815.32	+26	4815.58	5	n B	73.6842	4813.73	+12	4813.85	13.82	+16	4813.98
3	n D	45.9228	4823.29	+26	4823.55	4	n D	73.7416	4815.23	+11	4815.34	15.46	+16	4815.62
3	n D	45.7775	4827.89	+25	4828.14	3	nn D	73.9984	4823.74	+11	4823.85	23.70	+16	4823.86
3	n B	45.7108	4830.02	+25	4830.27	3	nn D	74.1264	4827.85	+10	4827.95	28.05	+16	4828.21
3	n D	45.6461	4832.08	+25	4832.33							30.30	+16	4830.46
1	D	45.3000	4843.19	+24	4843.43	6	n D	74.2666	4832.37	+10	4832.47	32.40	+16	4832.56
	nn D	44.9356	4855.05	+23	4855.28							43.46	+16	4843.62
												55.31	+16	4855.47
	nn D	44.4424	4871.35	+21	4871.56	1	n B	75.0324	4857.49	+6	4857.55	57.52	+16	4857.68
	nn D	44.3110	4875.74	+21	4875.95		D	75.4577	4871.75	+3	4871.78	71.67	+16	4871.83
4	n D	44.1501	4881.15	+20	4881.35							75.98	+16	4876.14
						2	n D	75.7421	4881.41	+1	4881.42	81.39	+16	4881.55
2-3	n D	43.5808	4900.54	+17	4900.71		nn D	75.8584	4885.39	0	4885.39	85.36	+16	4885.52
	wn D	42.9971	4920.85	+14	4920.99		nn D	76.3069	4900.89	-3	4900.86	00.79	+16	4900.95
1	nn D	42.8823	4924.91	+14	4925.05		nn D	76.8594	4920.35	-8	4920.27	20.62	+16	4920.78
1-2	n D	42.6213	4934.16	+12	4934.28									
	n D	41.9581	4958.13	+8	4958.21									
	nn D	40.8214	5000.66	+1	5000.67									

## 318 BIRMINGHAM

1914-15

1898. December 21. G. M.T. 21.7  
Hour angle, E 0h5  
Star track, 20.00 to 20.01

PLATE G 284

1899, January 20, G.M.T. 1748  
Hour angle E 237  
Star good; comparison fair

In- ten- sity	Char- acter	Mean Sun- dial Read- ing		Wave- Length by Form.		Cor- rected Curve	Wave- Length		I to S
		mm.	t.m.	mm.	t.m.		mm.	t.m.	
Begin		44 895	68 30	+22	68.52				
4	n D	44 740	68 14	+21	68 35				
	m D	44 5121	83 35	+18	83 41				
1	n D	44 3592	88 51	+16	88 67				
6	w D	44 2554	93 00	+15	93 15				
1	n D	44 0261	97 02	+11	97 07				
D	from 4 D to	43 7500	01 50	-11	01 61				
		43 9520	05 52	-10	05 62				
		43 8070	11 30	+ 8	11 38				
2 3	n D	43 6873	16 20	+ 5	16 25				
8	w D	43 4450	25 07	- 2	25 05				
2 3	n D	43 2543	31 03	- 9	31 04				
	n D	43 1159	39 54	-13	39 41				
2 3	n D	42 9223	47 51	-19	47 38				
2 3	n D	42 8385	54 59	-20	50 99				
2 3	n D	42 7533	55 52	-21	55 53				
2 3	n D	42 6843	60 46	-23	60 73				
1	n D	42 1687	74 02	-35	72 39				
1	n D	41 7417	87 20	-32	87 48				
2 3	n D	41 6562	92 15	-30	91 95				
1	n D	41 5699	96 05	-29	94 55				
2 3	n D	41 5405	96 75	-28	96 78				
2 3	n D	41 4952	97 42	-18	97 49				
2 3	n D	41 3590	15 01	-18	14 83				
2 3	n D	41 3043	17 41	-16	17 28				
5		41 0754	28 33	-12	28 41				
Max	B	40 9341	31 74	-11	31 03				
1	n D	40 8755	36 01	-10	36 54				
3	B	40 8759	38 81	- 8	38 76				
1	n D	40 7595	41 03	- 7	40 96				
2	n D	40 2927	66 17	+ 1	65 18				
3	n B	40 1854	68 37	+ 2	68 39				
6	n D	40 1225	71 50	+ 3	71 43				
6	n D	40 2828	74 29	+ 4	74 22				
2 3	n D	40 0934	79 58	+ 5	77 07				
6 8	n B	39 9500	72 38	+ 5	72 43				
Max	n D	39 5888	96 49	+ 9	96 58				
1	n D	39 4160	99 32	+11	99 43				
1	n D	39 3070	09 05	+11	10 08				
1	B	39 2649	12 16	+12	12 17				
2 3	n D	39 2738	15 02	+12	14 52				
2 3	n D	39 1788	16 32	+13	16 35				
2 3	n D	39 1602	19 80	+13	19 93				
6	n D	39 0425	22 46	+13	22 49				
5	n D	39 0410	24 30	+12	24 32				
5	n B	38 9332	26 24	+14	26 38				
5	n D	38 9027	29 70	+14	29 84				
5	n B	38 8060	31 90	+13	31 84				
1	n D	38 8435	35 02	+13	35 01				
1	n D	38 7418	37 63	+12	37 78				
1	from to	38 7180	38 80	+15	38 95				
6	n D	38 5890	45 29	+16	45 36				
6	n D	38 5846	47 38	+16	47 54				
6	n D	38 4880	50 24	+16	50 40				
1	n D	38 4334	53 08	+16	53 11				
1	n D	38 3210	58 46	+16	58 53				
1	n D	38 2808	60 41	+17	60 55				
1	B	38 2509	62 14	+17	62 41				
1	n D	38 1628	65 60	+17	66 15				
1	n D	38 0915	71 01	+18	71 41				
1	B	38 0804	73 34	+18	74 09				
6	n D	38 0000	81 00	+18	81 27				

PLATE G 379

1900, January 25, G.M.T. 20h7  
Hour angle. W 0h4  
Star fair: comparison good

[illegible]



318 BIRMINGHAM *Continued*

PLATE G 271						PLATE G 281						PLATE G 379						MEAN WAVE-LENGTH		
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor. for Velocity	Cor. for V	Cor. for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.	t.m.	t.m.
2	D	58.650	5783.37	-7	5782.41	...	wn D	32.6312	84.25	-11	84.11	...	...	...	...	...	84.22	+19	5781.41	
	D	58.650	5796.96	+6	5795.02	1	nn D	52.1000	98.90	-13	98.77	...	...	...	...	...	98.88	+19	5799.1	
	D	58.650	5817.35	+5	5816.02	1	nn D	32.1120	18.10	-14	18.26	...	...	...	...	...	18.33	+19	5818.5	
	D	58.650	5829.83	+5	5829.88	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	D	58.650	5841.05	+4	5841.11	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	D	58.650	5857.96	+4	5857.70	1	D	31.0093	48.31	-15	48.16	...	...	...	...	...	48.27	+19	5848.16	
	D	58.650	5881.30	+4	5881.31	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

## 74 SCHJELLERUP

PLATE G 483						PLATE G 591						WAVE-LENGTH from G 391 only		
1900, February 1, G.M.T. 1753. Hour angle, W 198 Star fair; comparison fair						1900, March 7, G.M.T. 1555. Hour angle, W 293 Star fair; comparison fair								
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
2 3	wn D	58.2020	4395.10	-21	4394.89	...	wn D	60.1865	4395.64	-51	4395.13	95.13	-7	4395.06
		...	...	...	...	...	wn D	60.1810	4401.50	-51	4400.79	00.79	-7	4400.72
	nn B	57.7867	4402.86	-22	4402.64	...	B	60.0825	4403.19	-51	4402.68	02.68	-7	4402.61
		...	...	...	...	limits		60.1200	4402.40	-51	4401.89	01.89	-7	4401.8
		...	...	...	...	limits		60.0200	4401.20	-51	4403.69	03.69	-7	4403.6
	nn D	57.1610	4409.00	-24	4408.76	...	nn D	59.9480	4405.70	-51	4405.19	05.19	-7	4405.12
	nn D	57.1240	4415.40	-25	4415.15	...	wn D	59.7610	4409.20	-52	4408.68	08.68	-7	4408.61
	nn D	56.4610	4428.10	-28	4427.82	3	nn D	59.1130	4415.90	-52	4415.38	15.38	-7	4415.31
	wn D	56.0640	4435.90	-28	4435.62	...	nn D	58.7620	4428.40	-52	4427.88	27.88	-7	4427.81
	nn D	55.3284	4450.50	-30	4450.20	5	nn D	58.6370	4431.01	-52	4430.49	30.49	-7	4430.42
		...	...	...	...	...	wn D	58.3920	4436.31	-52	4435.79	35.79	-7	4435.72
		...	...	...	...	...	nn D	57.7010	4449.46	-51	4448.95	48.95	-7	4448.88
		...	...	...	...	...	wn D	57.6272	4450.94	-51	4450.43	50.43	-8	4450.35
		...	...	...	...	...	nn D	57.3500	4456.40	-51	4455.89	55.89	-8	4455.81
		...	...	...	...	...	nn D	57.1490	4460.60	-51	4460.09	60.09	-8	4460.01
		...	...	...	...	...	nn D	57.0296	4463.07	-51	4462.56	62.56	-8	4462.48
		...	...	...	...	...	from	56.9690	4463.70	-51	4463.19	63.19	-8	4463.1
	wn B	54.6426	4464.39	-31	4464.08	B	to	56.9140	4465.40	-51	4464.89	64.89	-8	4464.8
	nn D	54.2796	4471.86	-32	4471.54	Max	B	56.4620	4474.80	-50	4474.30	74.30	-8	4474.2
	Max	B	53.9170	-32	4479.08	1	nn D	56.4000	4476.00	-50	4475.50	75.50	-8	4475.42
	Max	B	53.6900	-33	4483.87	1	nn D	56.1746	4480.80	-50	4480.30	80.30	-8	4480.22
		...	...	...	...	1	nn D	56.0743	4482.91	-49	4482.42	82.42	-8	4482.34
		...	...	...	...	1-2	nn D	55.8246	4488.18	-49	4487.69	87.69	-8	4487.61
		...	...	...	...	1	nn D	55.7699	4490.62	-49	4490.13	90.13	-8	4490.05
		...	...	...	...	2	nn D	55.3752	4497.77	-48	4497.29	97.29	-8	4497.21
		...	...	...	...	1 2	nn D	55.1543	4502.53	-48	4502.05	02.05	-8	4501.97
		...	...	...	...	from	55.1250	4503.10	-47	4502.63	02.63	-8	4502.5	
		...	...	...	...	B	to	54.9540	4506.80	-47	4506.33	06.33	-8	4506.3
		...	...	...	...	2 3	nn D	54.9215	4507.59	-47	4507.12	07.12	-8	4507.04
		...	...	...	...	1	nn D	54.7896	4510.46	-47	4509.99	09.99	-8	4509.91
		...	...	...	...	1	nn D	54.6799	4512.90	-47	4512.43	12.43	-8	4512.4
		...	...	...	...	1	nn B	54.4351	4518.25	-46	4517.79	17.79	-8	4517.71
		...	...	...	...	1 2	nn D	54.4082	4518.92	-46	4518.46	18.46	-8	4518.38
		...	...	...	...	s	nn B	54.2459	4522.45	-46	4521.99	21.99	-8	4521.91

## 74 SCHJELLERUP—Continued

PLATE G 383					PLATE G 391					WAVE-LENGTH from G 391 only				
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
1	nn D	51.8680	4523.57	-32	4523.25	2	nn D	54.1879	4523.73	-45	4523.28	23.28	-8	4523.20
1	D	51.6014	4529.52	-32	4529.20	0	nn D	54.0010	4527.90	-45	4527.45	27.45	-8	4527.4
B	from	51.2760	4536.90	-31	4536.59	1	nn D	53.8414	4531.48	-44	4531.04	31.04	-8	4530.96
Max	B	51.1430	4539.90	-31	4539.59	1	nn D	53.6220	4536.40	-44	4535.96	35.96	-8	4535.9
						B	to	53.5910	4537.10	-44	4536.66	36.66	-8	4536.6
						1-2	nn D	53.4450	4540.40	-44	4539.96	39.96	-8	4539.9
						B	from	53.4177	4541.08	-43	4540.65	40.65	-8	4540.57
								53.1430	4547.30	-43	4546.87	46.87	-8	4546.8
						B	to	53.0720	4549.00	-42	4548.58	48.58	-8	4548.5
	nn D	50.5253	4554.04	-29	4553.75		w D	52.8309	4554.56	-41	4554.15	54.15	-8	4554.07
Max	B	50.3232	4558.74	-29	4558.45	B	from	52.7730	4555.90	-41	4555.49	55.49	-8	4555.4
							to	52.5770	4560.40	-41	4559.99	59.99	-8	4559.9
							nn D	52.5555	4560.97	-41	4560.56	60.56	-8	4560.48
							nn D	52.4284	4563.95	-40	4563.55	63.55	-8	4563.47
						1	n D	52.3199	4566.22	-40	4565.82	65.82	-8	4565.74
							nn D	52.0600	4571.80	-39	4571.41	71.41	-8	4571.3
							nn D	51.8700	4578.10	-37	4577.73	77.73	-8	4577.7
							nn D	51.8370	4581.70	-35	4581.35	81.35	-8	4581.3
							nn D	51.1280	4585.12	-35	4584.77	84.77	-8	4584.69
						4	n B	51.0594	4586.78	-35	4586.43	86.23	-8	4586.15
						2	n B	50.9218	4600.17	-34	4599.83	99.83	-8	4599.75
						1	n D	50.8759	4601.29	-34	4600.95	100.95	-8	4600.86
						1	n B	50.8237	4602.58	-34	4602.24	102.24	-8	4602.16
						8	n B	50.6337	4607.29	-33	4606.96	106.96	-8	4606.88
	wn D	48.3246	4606.81	-21	4606.60	1	wn B	50.5428	4609.30	-32	4608.98	108.98	-8	4608.90
						5	n D	50.4861	4610.96	-32	4610.64	110.64	-8	4610.56
2	nn B	48.1030	4612.30	-20	4612.10	2	n D	50.3577	4614.17	-32	4613.85	113.85	-8	46

## 71 SCHJELLERUP - Continued

PLATE G 281						PLATE G 281						WAVE-LENGTH from G 281 only		
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
			t.m.		t.m.			mm.	t.m.		t.m.			t.m.
10	from	43.5460	4735.30	-24	4735.06	10	from	45.8880	4734.60	-20	4734.40	34.39	-8	4734.3
10	to	43.4640	4737.70	-24	4737.46	10	to	45.7790	4737.87	-20	4737.67	37.67	-8	4737.6
10	nn B	43.5625	4736.56	-24	4736.32	10	B	45.7400	4738.97	-20	4738.77	38.77	-8	4738.69
10	nn B	43.4117	4739.21	-25	4738.96	10	from	45.7070	4739.90	-20	4739.70	39.70	-8	4739.6
						10	to	45.6240	4742.40	-20	4742.20	42.20	-8	4742.1
	nn D	43.2249	4744.69	-26	4744.43	10	D	45.5649	4744.12	-20	4743.92	43.92	-8	4743.84
						10	from	45.6178	4742.56	-20	4742.36	42.36	-8	4742.3
						10	to	45.5043	4745.90	-19	4745.71	45.71	-8	4745.6
						10	B	45.5043	4745.90	-19	4745.71	45.71	-8	4745.6
						10	nn D	45.4034	4748.90	-19	4748.71	48.71	-8	4748.6
						10	from	45.3820	4749.50	-19	4749.31	49.31	-8	4749.23
						10	f. om	45.2410	4753.60	-19	4753.41	53.41	-8	4753.3
						10	to	45.0980	4757.90	-19	4757.71	57.71	-8	4757.6
	nn D	42.7371	4759.18	-20	4758.99	10	nn D	45.0587	4759.10	-19	4758.91	58.91	-8	4758.83
						10	from	45.0150	4760.10	-19	4760.21	60.21	-8	4760.1
						10	to	44.8240	4766.10	-19	4765.91	65.91	-8	4765.8
						10	nn D	44.8089	4766.60	-19	4766.41	66.41	-8	4766.33
						10	from	44.7800	4767.40	-19	4767.21	67.21	-8	4767.1
						10	to	44.6150	4772.40	-19	4772.21	72.21	-8	4772.1
	nn D	42.2610	4773.60	-32	4773.28	10	nn D	44.5834	4773.42	-19	4773.23	73.23	-8	4773.15
						10	from	44.5570	4774.20	-19	4774.01	74.01	-8	4773.9
						10	to	44.4160	4778.50	-19	4778.31	78.31	-8	4778.2
1	nn D	41.8012	4784.90	-34	4784.56	10	nn D	44.2150	4784.70	-19	4784.51	84.51	-8	4784.43
2	nn D	41.7176	4790.28	-36	4789.92	10	n D	44.0579	4789.53	-19	4789.34	89.34	-8	4789.26
10	from	41.6890	4791.20	-36	4790.84	10	from	44.0290	4790.40	-19	4790.21	90.21	-8	4790.1
	to					10	to	43.8300	4796.61	-19	4796.42	96.42	-8	4796.3
						10	n B	43.6348	4802.71	-19	4802.52	102.52	-8	4802.44
						10	n D	43.4940	4807.10	-20	4806.90	106.90	-8	4806.82
						10	n D	43.3270	4812.40	-20	4812.20	112.20	-8	4812.12

## 71 SCHJELLERUP

PLATE G 282						PLATE G 283						MEAN WAVE-LENGTH		
100, February 16, G.M.T. 1908. Hour angle, E. 21°						100, February 16, G.M.T. 1908. Hour angle, W. 65°						Star poor - comparison fair		
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
			t.m.		t.m.			mm.	t.m.		t.m.			t.m.
3	n D	49.4320	5173.44	-16	5173.28	3 4	D	45.1046	5173.79	-48	5173.31	73.30	-9	5173.21
	from	49.2190	5182.20	-17	5182.03							81.83	-9	5181.7
							D	44.8410	5181.50	-50	5181.00	84.20	-9	5184.11
	to	49.200	5186.00	-17	5185.83							85.63	-9	5185.5
Con.	from	49.1240	5186.00	-17	5185.83							85.63	-9	5185.5
							D	44.7210	5189.50	-50	5189.00	89.20	-9	5189.11
Spec.		48.9780	5191.80	-17	5191.73							91.53	-9	5191.4
1	D	48.9444	5193.32	-18	5193.14		D	44.6200	5193.60	-51	5193.09	93.12	-9	5193.03
Max	B	48.8394	5197.65	-18	5197.47							97.27	-9	5197.18
	from	48.6610	5200.15	-19	5204.91							104.71	-9	5204.6
	D						D	44.2120	5210.60	-52	5210.08	108.28	-9	5210.19
	to	48.4010	5211.68	-19	5211.41							111.21	-9	5211.1
	from	48.4780	5212.70	-19	5212.51							121.31	-9	5212.2
	B											16.67	-9	5216.58
	to	48.1620	5224.70	-20	5224.50		D	44.0580	5217.00	-53	5216.47	24.30	-9	5224.2
6 8	D	48.1460	5226.06	-20	5226.16							26.26	-9	5226.17
	from	48.0860	5229.40	-20	5230.40		nn D	43.8320	5226.60	-54	5226.06	28.90	-9	5228.8
	to	47.9820	5233.78	-20	5233.68							33.38	-9	5233.3

## 74 SCHJELLERUP—Continued

PLATE G 373						PLATE G 386						MEAN WAVE-LENGTH			
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.	
2	n D	47.9641	5234.44	-20	5234.24	D?	43.6420	5234.70	-55	5234.15	34.04	-9	5233.95		
2	n B	47.8913	5237.56	-21	5237.35						37.15	-9	5237.06		
2	nn D	47.8283	5240.27	-21	5240.06	D?	43.4970	5240.90	-55	5240.35	40.21	-9	5240.12		
3	nn B	47.7130	5245.30	-21	5245.09						44.89	-9	5244.80		
3	n D	47.6561	5247.69	-21	5247.48	D?	43.3360	5247.90	-56	5247.34	47.41	-9	5247.32		
3	n D	47.5628	5252.17	-21	5251.96	D?	43.2400	5252.10	-56	5251.54	51.75	-9	5251.66		
3	wn D	47.1322	5270.59	-22	5270.37	wn D	42.8150	5270.70	-56	5270.14	70.26	-9	5270.17		
1	n D	46.8311	5284.42	-22	5284.20						84.00	-9	5283.91		
1	nn D	46.5147	5298.21	-22	5297.99						97.79	-9	5297.70		
1-2	n D	46.4066	5302.98	-22	5302.76						92.56	-9	5302.47		
1	nn D	46.3064	5307.68	-22	5307.46	1 2	n D	41.8151	5315.81	-55	5315.26	15.39	-9	5315.30	
1	n D	46.1307	5315.73	-22	5315.51	1	B	41.7738	5317.72	-54	5317.18	17.59	-9	5317.50	
8	n B	46.0765	5318.22	-22	5318.00	1 2	n D	41.7014	5321.06	-54	5320.52	20.72	-9	5320.63	
2-3	n D	45.8363	5329.34	-21	5329.13	2	n D	41.5178	5329.59	-54	5329.05	29.09	-9	5329.00	
2	nn D	45.6677	5337.22	-21	5337.01	nn D	41.3590	5337.00	-53	5336.47	36.74	-9	5336.65		
4	n B	45.6254	5339.20	-21	5338.99						38.79	-9	5338.70		
2	n D	45.5680	5341.90	-21	5341.69	1 2	n D	41.2588	5341.72	-53	5341.19	41.44	-9	5341.35	
2	n D	45.3895	5350.32	-20	5350.12						49.92	-9	5349.83		
							nn D	40.8260	5362.30	-52	5361.78	61.98	-9	5361.89	
1	n D	45.0436	5366.84	-19	5366.65						66.45	-10	5366.35		
5	D	44.9377	5371.94	-19	5371.75	6	wn D	40.6243	5372.00	-51	5371.49	71.62	-10	5371.52	
8	n B	44.8721	5375.11	-19	5374.92	2	nn B	40.5560	5375.30	-51	5374.79	74.86	-10	5374.76	
2	n D	44.8173	5377.77	-19	5377.58	2	nn D	40.5028	5377.89	-51	5377.38	77.48	-10	5377.38	
6	n B	44.7632	5380.39	-18	5380.21						80.01	-10	5379.91		
							nn D	40.3560	5385.10	-51	5384.59	84.79	-10	5384.69	
3	n B	44.4953	5393.49	-18	5393.31						93.11	-10	5393.01		
3	D	44.4056	5397.92	-17	5397.75	2	n D	40.1023	5397.51	-50	5397.01	97.38	-10	5397.28	
B	from	44.3790	5399.30	-17	5399.13						98.93	-10	5398.8		
1	to	44.2480	5405.80	-17	5405.63						105.43	-10	5405.3		
3 4	n D	44.2273	5406.75	-17	5406.58						106.38	-10	5406.28		
1	n B	44.1450	5410.85	-16	5410.69	1 2	n D	39.8383	5410.62	-49	5410.13	10.41	-10	5410.31	
6	n B	44.1064	5412.78	-16	5412.62						12.42	-10	5412.32		
3	n D	44.0135	5417.43	-16	5417.27	2 3	n B	39.7022	5417.44	-49	5416.95	17.11	-10	5417.01	
2 3	n B	43.9562	5420.31	-16	5420.15	3 4	n D	39.6523	5419.95	-49	5419.36	19.76	-10	5419.66	
2	n B	43.8945	5423.42	-15	5423.27						23.07	-10	5422.97		
3 4	n D	43.8128	5427.54	-15	5427.39						27.19	-10	5427.09		
1	n B	43.7561	5430.42	-15	5430.27	3	n D	39.4508	5430.14	-48	5429.66	29.97	-10	5429.87	
2	n B	43.7176	5432.59	-15	5432.44						32.24	-10	5432.14		
2	nn D	43.6727	5434.66	-15	5434.51	1 2	n D	39.3618	5434.67	-48	5434.19	34.35	-10	5434.25	
						1	n D	39.2880	5438.44	-48	5437.96	38.16	-10	5438.06	
B	from	43.5690	5439.00	-15	5438.85						38.65	-10	5438.55		
6	to	43.4420	5446.50	-14	5446.36						46.16	-10	5446.06		
2	n D	43.4057	5448.34	-14	5448.20	5	n D	39.0952	5448.34	-47	5447.87	48.04	-10	5447.94	
1 2	n D	43.2348	5457.16	-14	5457.02	2-3	n D	38.9332	5456.73	-47	5456.26	56.64	-10	5456.54	
1	n D	43.1981	5459.07	-14	5458.93						58.73	-10	5458.63		
1	B	43.1647	5460.81	-14	5460.67	2	D	38.8511	5460.98	-47	5460.51	60.59	-10	5460.49	
B	from	43.1480	5461.80	-14	5461.66						61.46	-10	5461.4		
1	to	43.0650	5466.60	-14	5466.46						66.26	-10	5466.2		
3	n B	43.0384	5467.40	-14	5467.26	wn D	38.7040	5468.70	-47	5468.23	67.75	-10	5467.6		
2	nn D	42.9469	5472.20	-13	5472.07	1	n B	38.6393	5472.08	-47	5471.61	71.87	-10	5471.77	
1	n D	42.8981	5474.76	-13	5474.63						74.43	-10	5474.33		
2	n D	42.8307	5478.32	-13	5478.19						77.99	-10	5477.89		
4	n B	42.7858	5480.68	-13	5480.55						80.35	-10	5480.25		
1	nn D	42.7422	5483.00	-13	5482.87	1 2	nn D	38.4319	5483.03	-46	5482.57	82.74	-10	5482.64	
3	n D	42.4573	5498.19	-13	5498.06	1	n D	38.2764	5491.31	-46	5490.85	91.05	-10	5490.95	
2	n D	42.3813	5502.28	-13	5502.15	2	n D	38.1497	5498.10	-46	5497.64	97.85	-10	5497.75	
1	n D	42.2922	5507.08	-12	5506.96	2	n D	38.0748	5502.13	-46	5501.67	101.91	-10	5501.81	
2	n B	42.2556	5509.06	-12	5508.94						106.76	-10	5506.66		
1	nn D	42.1895	5512.64	-12	5512.52	2	nn D	37.8800	5512.70	-46	5512.24	12.38	-10	5512.28	
1	wn D	41.9690	5524.68	-12	5524.56	1	n D	37.6637	5524.48	-46	5524.02	24.29	-10	5524.19	
2	n B	41.8372	5531.92	-12	5531.80						31.60	-10	5531.50		
1	n D	41.8017	5533.88	-12	5533.76						33.76	-10	5533.66		
8	wn D	41.6850	5539.79	-12	5539.67	8	wn D	37.3918	5539.49	-46	5539.03	39.35	-10	5539.25	

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TABLE G 203										PLATE G 282										MEAN WAVE-LENGTH			
Line	Ident.	Wave- Length by Formula	Wave- Length by Interpolat.	Cor. from Curve	Wave- Length	In- ter- stry	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity			Cor. for V	Corrected for Velocity							
												t.m.	nm.	t.m.									
Mars	B	41.0172	5544.11	-12	5543.99	1 2	nn B	37.3140	5543.80	-46	5543.34	43.67	-10	5543.57									
1	nn D	41.4058	5552.02	-12	5552.50							52.30	-10	5552.20									
1	nn B	41.4334	5554.39	-12	5554.27	1	B	37.1284	5554.21	-46	5553.75	54.01	-10	5553.91									
1	nn D	41.4000	5556.22	-12	5556.10							55.90	-10	5555.80									
1 2	B	41.2419	5565.19	-13	5565.06	1	B	36.9659	5565.07	-46	5564.61	64.83	-10	5564.73									
1 2	nn D	41.2081	5567.10	-13	5566.97	2	n D	36.9050	5566.82	-46	5566.36	66.67	-10	5566.57									
1 2	nn D	41.1502	5570.39	-13	5570.26							70.06	-10	5569.96									
2	D	40.9075	5581.55	-13	5581.42	9	D	36.7830	5573.77	-46	5573.31	73.51	-10	5573.41									
4	B	40.8559	5587.24	-13	5587.11	3	n B	36.6009	5584.20	-46	5583.74	84.08	-10	5583.98									
1	n D	40.8231	5589.13	-13	5589.00	1	n D	36.5076	5587.32	-46	5586.86	86.99	-10	5586.89									
1	n D	40.7252	5594.79	-13	5594.66	1	nn D	36.5076	5589.58	-46	5589.14	89.07	-10	5588.97									
3	n B	40.6885	5598.08	-14	5598.00	4	nn B	36.4000	5595.24	-46	5594.78	94.72	-10	5594.62									
1	nn D	40.6351	5600.02	-14	5599.88							97.47	-10	5597.37									
2	nn D	40.4658	5609.91	-14	5609.77	1	n D	36.3717	5597.45	-46	5596.99	99.68	-10	5599.58									
								from	36.1591	5609.88	-47	5609.41	109.59	-10	5609.19								
								to	36.0070	5618.90	-47	5618.43	118.63	-10	5618.5								
3	n D	40.2844	5620.60	-15	5620.45	3 4	nn D	35.8770	5626.50	-48	5626.02	26.22	-10	5626.1									
4	nn D	40.2078	5625.13	-15	5624.98	5	nn D	35.9767	5620.63	-48	5620.15	20.30	-10	5620.20									
1	from	40.1750	5627.09	-15	5626.94	Con. 5	from	35.8986	5625.26	-48	5624.78	24.88	-10	5624.78									
1	to	40.0810	5632.70	-15	5632.55	Sec. 10	to	35.8710	5626.90	-48	5626.42	26.68	-10	5626.6									
1	w D	40.0467	5634.73	-15	5634.58	10	nn D	35.7700	5632.40	-48	5631.92	32.24	-10	5632.1									
Head		40.0051	5637.22	-16	5637.06	Head		35.7436	5634.50	-48	5634.02	34.30	-10	5634.20									
								35.7024	5636.97	-48	5636.49	36.78	-10	5636.68									
						2	n B	35.6791	5638.37	-48	5637.89	38.06	-10	5637.90									
						2	n D	35.6555	5639.79	-48	5639.31	39.51	-10	5639.41									
						2	n B	35.6231	5641.71	-48	5641.23	41.43	-10	5641.33									
2	n D	39.8922	5644.00	-16	5643.84	2	n D	35.5812	5644.25	-48	5643.77	43.81	-10	5643.71									
1	from	39.8729	5645.30	-16	5645.14							44.94	-10	5644.84									
B						1	nn D	35.4822	5650.21	-49	5649.75	49.05	-10	5649.85									
1	to	39.6670	5657.64	-17	5657.47							57.27	-10	5657.2									
1	n D	39.6549	5658.37	-17	5658.20	3	n D	35.3383	5658.98	-49	5658.49	58.35	-10	5658.25									
						4	nn D	35.1314	5671.66	-50	5671.16	71.36	-10	5671.26									
2	B	39.3863	5674.83	-18	5674.65							74.45	-10	5674.35									
2	nn D	39.3490	5677.29	-18	5677.11	2	n D	35.0436	5677.07	-50	5676.57	76.84	-10	5676.74									
1	B	39.3071	5679.72	-18	5679.54							79.34	-10	5679.24									
1	nn D	39.1803	5687.59	-19	5687.40	1	nn D	34.8822	5687.09	-51	5686.58	86.99	-10	5686.89									
1	n B	39.0737	5694.25	-19	5694.06	5	n B	34.7734	5693.88	-51	5693.37	93.72	-10	5693.62									
1	B	38.9700	5700.75	-19	5700.56							100.36	-10	5700.26									
2	B	38.8886	5705.88	-20	5705.68	3	n B	34.5880	5705.54	-52	5705.02	105.35	-10	5705.25									
2	nn D	38.8099	5708.96	-20	5708.76	2	n D	34.5358	5708.84	-52	5708.32	108.54	-10	5708.44									
1	B	38.7000	5711.55	-20	5711.35							115.15	-10	5711.05									
2	n D	38.7082	5713.50	-20	5713.30	1	n D	34.4673	5713.18	-52	5712.66	12.98	-10	5712.88									
1	nn D	38.6905	5717.87	-20	5717.67	4	nn B	34.4006	5717.43	-53	5716.90	17.29	-10	5717.19									
1	n D	38.6099	5721.92	-20	5721.72	2	n D	34.3372	5721.47	-53	5720.94	21.33	-10	5721.23									
3	n B	38.5916	5724.37	-20	5724.37							24.17	-10	5724.07									
								from	34.2510	5727.00	-53	5726.47	26.67	-10	5726.6								
2	n D	38.4744	5732.28	-22	5732.06	D	to	34.1150	5733.80	-54	5733.26	31.86	-10	5731.76									
												33.46	-10	5733.4									
												37.19	-10	5737.09									
M	B	38.3820	5737.61	-22	5737.39							44.06	-10	5743.96									
1	nn D	38.2899	5744.48	-22	5744.26							62.76	-10	5762.66									
1	n D	38.1748	5762.92	-24	5762.68		nn D	33.6910	5763.40	-56	5762.84	71.69	-10	5771.59									
1	nn D	38.0645	5772.13	-24	5771.89		nn D	33.5719	5771.96	-56	5771.40	77.96	-10	5777.86									
1	nn D	37.7701	5778.40	-24	5778.16							73.50	-10	5773.5									
B	from	37.8770	5774.00	-24	5773.76							82.05	-10	5782.0									
1	from	37.7000	5782.50	-25	5782.25							82.05	-10	5782.0									
D	to	37.5710	5791.80	-25	5791.55							91.35	-10	5791.3									
1	nn D	37.4625	5798.06	-25	5797.80							98.60	-10	5798.50									
2	n D	37.1044	5823.47	-25	5823.22							23.02	-10	5822.92									

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PLATE G 34						PLATE G 32						MEAN WAVE-LENGTH		
1899, October 4, G.M.T. 20h ±. Hour angle, E. 3h ±. Star good; comparison excellent						1900, March 21, G.M.T. 18h ±. Hour angle, E. 3h ±. Star excellent; comparison good								
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
...	...	...	...	...	...	1	nn D	53.6860	4388.20	-40	4387.80	87.60	+1	4387.6
...	...	...	...	...	...	2	D	53.5655	4390.41	-40	4390.01	89.81	+1	4389.82
...	wn D	61.6970	4395.00	+29	4395.29	8	w D	53.3033	4395.30	-42	4394.88	95.09	+1	4395.10
...	wn D	61.4100	4400.40	+28	4400.68	1	nn D	52.9584	4401.77	-44	4401.33	01.13	+1	4401.14
2	n B	61.3173	4402.19	-28	4402.47	...	nn D	52.7441	4405.82	-45	4405.37	02.67	+1	4402.68
...	nn D	61.1835	4404.75	-27	4405.02	...	nn D	52.5500	4409.40	-46	4408.94	05.20	+1	4405.21
...	wn D	60.6560	4414.90	+25	4415.15	3	nn D	52.2179	4415.87	-49	4415.38	08.74	+1	4408.75
...	nn D	60.3900	4420.10	-24	4420.34	3	wn D	...	...	...	15.17	+1	4415.18	
...	wn D	60.2630	4422.50	-23	4422.73	...	...	...	...	...	20.54	+1	4420.55	
...	nn D	60.0696	4425.81	-23	4426.04	...	...	...	...	...	22.93	+1	4422.94	
...	nn D	60.0268	4427.25	-22	4427.47	...	...	...	...	...	26.24	+1	4426.25	
...	nn D	59.8865	4430.03	-22	4430.25	1	nn D	51.5790	4428.28	-52	4427.76	27.62	+1	4427.63
...	wn D	59.6087	4435.56	-22	4435.78	1	nn D	51.4412	4430.98	-52	4430.46	30.36	+1	4430.37
6	n B	59.4958	4437.82	-21	4438.03	7	wn D	51.1578	4436.58	-54	4436.04	35.91	+1	4435.92
...	n B	59.4438	4438.87	-21	4439.08	...	...	...	...	...	38.13	+1	4438.14	
2	nn D	59.2985	4441.80	-21	4442.01	3	nn B	50.9694	4440.32	-55	4439.77	39.43	+1	4439.44
...	n D	59.1816	4444.16	-21	4444.37	...	...	...	...	...	42.21	+1	4442.22	
2	nn D	59.0300	4447.24	-21	4447.45	...	...	...	...	...	44.57	+1	4444.58	
...	n B	58.9710	4448.44	-21	4448.65	3	nn B	50.5042	4449.65	-57	4449.08	47.65	+1	4447.66
...	nn D	58.9028	4449.83	-20	4450.03	3	n D	50.4299	4451.15	-58	4450.57	48.87	+1	4448.88
...	...	...	...	...	...	3	nn D	50.2897	4453.99	-58	4453.41	50.30	+2	4450.32
...	nn D	58.6457	4455.10	+20	4455.30	0-1	nn D	50.1773	4456.28	-58	4455.70	53.21	+2	4453.23
...	nn D	58.5558	4456.95	+20	4457.15	2	n D	...	...	...	55.50	+2	4455.52	
...	n D	58.4162	4459.84	-20	4460.04	...	...	...	...	...	57.35	+2	4457.37	
...	wn D	58.3197	4461.84	-19	4462.03	1	n D	49.9639	4460.64	-59	4460.05	60.05	+2	4460.07
...	...	...	...	...	...	B	from	49.8485	4463.01	-60	4462.41	62.22	+2	4462.24
...	n B	58.2285	4463.73	+19	4463.92	3	B	49.8130	4463.70	-60	4463.10	62.90	+2	4462.9
...	...	...	...	...	...	2	B	49.7850	4464.32	-60	4463.72	63.82	+2	4463.84
...	...	...	...	...	...	...	to	49.7337	4465.40	-61	4464.79	64.59	+2	4464.61
...	...	...	...	...	...	1	n D	49.7060	4465.90	-61	4465.29	65.09	+2	4465.1
...	...	...	...	...	...	1	n D	49.6959	4466.16	-61	4465.55	65.35	+2	4465.37
...	nn D	57.8730	4471.17	+19	4471.36	...	...	49.5359	4469.48	-62	4468.86	68.66	+2	4468.68
1	nn D	57.6893	4475.05	+19	4475.24	...	...	...	...	...	71.56	+2	4471.58	
...	n D	57.3620	4482.00	+19	4482.19	1	nn D	49.2210	4476.00	-63	4475.37	75.31	+2	4475.33
3	nn D	57.1250	4487.10	+20	4487.30	1	nn D	48.9834	4481.03	-64	4480.39	80.19	+2	4480.21
...	n D	57.0200	4489.35	+20	4489.55	1	nn D	48.8964	4482.87	-64	4482.23	82.21	+2	4482.23
3	n D	56.8895	4496.51	-21	4496.72	1	nn D	48.6291	4488.54	-65	4487.89	87.60	+2	4487.62
...	nn D	56.4587	4501.56	-21	4501.77	2	nn D	48.5244	4490.78	-65	4490.13	89.84	+2	4489.86
...	from	56.4250	4502.30	-21	4502.51	4	n D	48.1953	4497.84	-66	4497.18	96.95	+2	4496.97
E	...	...	...	...	...	1	nn D	47.9757	4502.59	-66	4501.93	01.85	+2	4501.87
...	to	56.2640	4506.80	+21	4506.01	...	...	...	...	...	02.71	+2	4502.7	
3 4	nn D	56.2317	4506.56	+22	4506.78	1	nn D	47.8508	4505.31	-67	4504.64	04.44	+2	4504.46
B	from	56.1860	4507.90	+22	4508.12	...	wn D	47.7265	4508.03	-67	4507.36	06.21	+2	4506.2
...	...	...	...	...	...	4	wn B	47.6564	4509.56	-67	4508.89	07.07	+2	4507.09
...	to	56.0210	4511.20	+22	4511.42	1	nn D	47.6052	4510.69	-67	4510.02	08.30	+2	4508.3
...	nn D	55.9620	4512.53	+22	4512.75	...	...	...	...	...	08.69	+2	4508.71	
1	n B	55.7663	4516.61	-23	4516.84	...	wn D	47.4594	4514.03	-67	4513.36	09.82	+2	4509.84
2	n D	55.7193	4517.96	-23	4518.19	2	n B	47.2719	4518.04	-67	4517.37	11.60	+2	4511.6
...	n B	55.5632	4521.47	-23	4521.70	2 3	n D	47.2758	4519.50	-67	4518.83	13.06	+2	4513.08
3	n D	55.5050	4522.79	-23	4523.02	5-6	n B	47.0622	4522.70	-67	4522.03	17.11	+2	4517.13
...	...	...	...	...	...	4	n D	47.0011	4524.07	-67	4523.40	18.51	+2	4518.53
3 4	n B	55.4268	4524.56	+23	4524.79	B	from	46.9620	4524.90	-67	4524.23	21.87	+2	4521.89
...	...	...	...	...	...	...	to	46.8810	4526.80	-67	4526.13	23.21	+2	4523.23
...	wn D	55.3178	4527.03	-24	4527.27	...	wn D	46.8047	4528.48	-67	4527.81	24.03	+2	4524.1
1	n D	55.1501	4530.84	-24	4531.08	...	nn D	46.6404	4532.18	-67	4531.51	25.93	+2	4526.0
D	Max	54.9528	4535.36	-25	4535.61	2	nn D	46.4529	4536.42	-67	4535.75	27.74	+2	4527.56
...	to	54.9150	4536.20	-25	4536.45	...	...	...	...	...	31.90	+2	4531.32	
1	B	54.8867	4536.88	-25	4537.13	...	...	...	...	...	33.05	+2	4533.1	
1	n B	54.8070	4538.72	-25	4538.97	3	n B	46.3675	4538.14	-67	4537.47	35.68	+2	4535.70
...	nn D	54.7461	4540.13	-26	4540.39	4	n B	46.2957	4540.00	-66	4539.34	36.65	+2	4536.7
1	B	54.5893	4543.76	+27	4544.03	3	n D	46.2280	4541.55	-66	4540.89	37.30	+2	4537.32
...	...	...	...	...	...	...	...	...	...	...	39.16	+2	4539.18	
...	...	...	...	...	...	...	...	...	...	...	40.64	+2	4540.66	
...	...	...	...	...	...	...	...	...	...	...	44.23	+2	4544.25	

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PLATE G 34										PLATE G 32										MEAN WAVE-LENGTH		
Line	Star	M. S. R.	Wave-length, Å.	Cor. from Curve	Wave-length, Å.	Intensity	Character	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length, Å.	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	t.m.	t.m.	t.m.	t.m.	t.m.			
3	n B	54.4385	4547.24	+27	4547.51	2	n B	45.9217	4548.60	-66	4547.94	47.73	+2	4547.75	47.73	+2	4547.75	47.73	+2	4547.75		
7	n B	54.3776	4548.69	+27	4548.96	3	wn D	45.8536	4550.16	-66	4549.50	49.23	+2	4549.25	49.23	+2	4549.25	49.23	+2	4549.25		
	n B	54.2122	4553.57	+28	4553.85		wn D	45.6729	4554.36	-66	4553.70	53.77	+2	4553.3	53.77	+2	4553.3	53.77	+2	4553.3		
1	n B	53.9700	4558.14	+29	4558.43	B	from	45.5990	4556.10	-66	4555.44	55.24	+2	4555.05	55.24	+2	4555.05	55.24	+2	4555.05		
	n B	53.9010	4559.91	+29	4560.20	4	to	45.4110	4560.50	-65	4559.85	58.63	+2	4559.7	58.63	+2	4559.7	58.63	+2	4559.7		
1 2	n D	53.7717	4562.99	+30	4563.29	3 4	n D	45.3734	4561.35	-65	4560.70	60.45	+2	4560.47	60.45	+2	4560.47	60.45	+2	4560.47		
1	n D	53.6837	4565.06	+30	4565.36	2	n B	45.3065	4562.93	-65	4562.28	62.08	+2	4562.10	62.08	+2	4562.10	62.08	+2	4562.10		
B	from	53.4590	4565.60	-30	4565.90	1	n D	45.2464	4564.34	-65	4563.69	63.49	+2	4563.51	63.49	+2	4563.51	63.49	+2	4563.51		
to	n D	53.4860	4569.80	+32	4570.12	2	n B	45.1954	4565.54	-65	4564.89	64.69	+2	4564.71	64.69	+2	4564.71	64.69	+2	4564.71		
	n D	53.3857	4572.00	+33	4572.33		from	45.1568	4566.46	-65	4565.81	65.59	+2	4565.61	65.59	+2	4565.61	65.59	+2	4565.61		
D	from	53.3110	4574.00	+34	4574.34	B	to	45.1310	4567.10	-65	4566.45	66.25	+2	4566.3	66.25	+2	4566.3	66.25	+2	4566.3		
to	n D	53.1950	4577.50	+35	4577.85	1	from	44.9620	4571.10	-64	4570.46	70.26	+2	4570.3	70.26	+2	4570.3	70.26	+2	4570.3		
1	n D	53.0742	4579.78	+35	4580.13	1 2	n D	44.6688	4578.80	-64	4577.44	72.53	+2	4577.26	72.53	+2	4577.26	72.53	+2	4577.26		
1	n B	52.9905	4581.75	+36	4582.11	1 2	to	44.6390	4578.80	-64	4578.16	74.54	+2	4578.0	74.54	+2	4578.0	74.54	+2	4578.0		
1	n B	52.9259	4583.40	+36	4583.76	4	n B	44.5807	4580.19	-64	4579.55	77.24	+2	4579.37	77.24	+2	4579.37	77.24	+2	4579.37		
1	n B	52.8595	4585.03	+37	4585.40	1	n D	44.5286	4581.45	-64	4580.81	80.45	+2	4580.47	80.45	+2	4580.47	80.45	+2	4580.47		
	n B	52.8595	4585.03	+37	4585.40	1	n B	44.4855	4582.49	-63	4581.86	81.66	+2	4581.68	81.66	+2	4581.68	81.66	+2	4581.68		
	n B	52.8595	4585.03	+37	4585.40	1	n D	44.4433	4583.50	-63	4582.87	82.49	+2	4582.51	82.49	+2	4582.51	82.49	+2	4582.51		
	n B	52.8595	4585.03	+37	4585.40	1	B	44.3945	4584.69	-63	4584.06	83.91	+2	4583.93	83.91	+2	4583.93	83.91	+2	4583.93		
	n B	52.8595	4585.03	+37	4585.40	1	n D	44.2755	4587.57	-63	4586.91	85.00	+2	4586.76	85.00	+2	4586.76	85.00	+2	4586.76		
	n B	52.8595	4585.03	+37	4585.40	1	B	44.1490	4590.65	-62	4590.03	86.74	+2	4589.85	86.74	+2	4589.85	86.74	+2	4589.85		
1	n D	52.6253	4590.79	+38	4591.17	1	n B	43.9869	4596.82	-62	4596.20	91.37	+2	4596.04	91.37	+2	4596.04	91.37	+2	4596.04		
2	wn B	52.4377	4595.44	+40	4595.84	6	n B	43.8969	4596.82	-62	4596.20	93.00	+2	4595.93	93.00	+2	4595.93	93.00	+2	4595.93		
1	n D	52.3860	4596.70	+40	4597.10	1	n B	43.7630	4600.12	-61	4599.51	96.02	+2	4599.33	96.02	+2	4599.33	96.02	+2	4599.33		
2	n D	52.2386	4600.40	+42	4600.82	2	n B	43.6968	4601.75	-61	4601.14	98.08	+2	4601.00	98.08	+2	4601.00	98.08	+2	4601.00		
2	n D	52.1938	4606.54	+44	4606.98	1	n D	43.6087	4603.93	-61	4603.32	100.78	+2	4603.14	100.78	+2	4603.14	100.78	+2	4603.14		
D	from	52.1630	4612.30	+42	4612.72	4 5	n D	43.4458	4607.98	-60	4607.38	103.18	+2	4607.20	103.18	+2	4607.20	103.18	+2	4607.20		
Head	n B	51.9431	4607.80	+44	4608.24	1	Head	43.4110	4608.80	-60	4608.20	105.22	+2	4608.03	105.22	+2	4608.03	105.22	+2	4608.03		
2	n B	51.9159	4608.54	+44	4608.98	1	n B	43.3758	4614.74	-59	4614.15	108.15	+2	4613.98	108.15	+2	4613.98	108.15	+2	4613.98		
1	n B	51.8746	4609.55	+45	4610.00	2	n B	43.3268	4615.97	-59	4615.38	110.20	+2	4615.21	110.20	+2	4615.21	110.20	+2	4615.21		
1	n B	51.7922	4611.64	+45	4612.09	1	n B	43.2757	4617.21	-58	4616.63	112.29	+2	4616.46	112.29	+2	4616.46	112.29	+2	4616.46		
2	n B	51.7297	4613.30	+46	4613.76	2	n D	43.2268	4618.46	-58	4617.88	114.38	+2	4617.71	114.38	+2	4617.71	114.38	+2	4617.71		
2	n B	51.6784	4614.53	+47	4615.00	2	n B	43.1757	4619.71	-58	4619.12	116.43	+2	4618.95	116.43	+2	4618.95	116.43	+2	4618.95		
2	n B	51.6215	4615.98	+47	4616.45	3 4	n B	43.1268	4620.96	-58	4620.37	118.48	+2	4620.20	118.48	+2	4620.20	118.48	+2	4620.20		
2	n B	51.5707	4617.28	+48	4617.76	6	n B	43.0757	4622.21	-58	4621.62	120.53	+2	4621.45	120.53	+2	4621.45	120.53	+2	4621.45		
2	n B	51.5014	4619.05	+48	4619.53	5	n B	43.0268	4623.46	-58	4622.87	122.58	+2	4622.70	122.58	+2	4622.70	122.58	+2	4622.70		
2	n B	51.4338	4620.78	+48	4621.26	6	n B	42.9757	4624.71	-57	4624.12	124.63	+2	4623.95	124.63	+2	4623.95	124.63	+2	4623.95		
2	n B	51.3778	4622.22	+49	4622.71	2	n D	42.9268	4625.96	-57	4625.37	126.68	+2	4625.20	126.68	+2	4625.20	126.68	+2	4625.20		
2	n B	51.3108	4623.87	+50	4624.37	3	n B	42.8757	4627.21	-57	4626.62	128.73	+2	4626.45	128.73	+2	4626.45	128.73	+2	4626.45		
2	n B	51.2438	4625.42	+51	4625.92	2	n D	42.8268	4628.46	-57	4627.87	130.78	+2	4627.70	130.78	+2	4627.70	130.78	+2	4627.70		
2	n B	51.1820	4627.20	+51	4627.71	1	wn D	42.7757	4629.71	-56	4629.12	132.83	+2	4628.95	132.83	+2	4628.95	132.83	+2	4628.95		
2	n B	51.1090	4629.10	+51	4629.61	1	n B	42.7268	4630.96	-56	4630.37	134.88	+2	4630.20	134.88	+2	4630.20	134.88	+2	4630.20		
2	n B	50.7546	4638.40	+54	4638.94	1	n B	42.6757	4632.21	-55	4631.62	136.93	+2	4631.45	136.93	+2	4631.45	136.93	+2	4631.45		
2	n B	50.6860	4639.84	+55	4640.38	5	n B	42.6268	4633.46	-55	4632.87	138.98	+2	4632.70	138.98	+2	4632.70	138.98	+2	4632.70		
2	n B	50.6130	4641.34	+55	4641.88	3	n B	42.5757	4634.71	-55	4634.12	141.03	+2	4633.95	141.03	+2	4633.95	141.03	+2	4633.95		
1	n B	50.5783	4643.04	+56	4643.60	1	n B	42.5268	4635.96	-55	4635.37	143.08	+2	4635.20	143.08	+2	4635.20	143.08	+2	4635.20		
2	n B	50.5090	4655.76	+59	4656.35	1	n D	41.9676	4647.26	-53	4646.67	145.13	+2	4646.50	145.13	+2	4646.50	145.13	+2	4646.50		
2	n B	49.7716	4634.60	+62	4635.22	1	n D	41.9187	4648.51	-53	4647.92	147.18	+2	4647.75	147.18	+2	4647.75	147.18	+2	4647.75		
1	n D	49.6901	4637.73	+62	4638.35	1	n D	41.8698	4649.76	-53	4649.17	149.23	+2	4648.99	149.23	+2	4648.99	149.23	+2	4648.99		
1	n D	49.6086	4713.96	+72	4714.68	1	n D	41.8209	4651.01	-53	4650.42	151.28	+2	4650.25	151.28	+2	4650.25	151.28	+2	4650.25		
1	n D	49.5271	4715.30	+73	4716.03	1	n D	41.7720	4652.26	-53	4651.67	153.33	+2	4651.50	153.33	+2	4651.50	153.33	+2	4651.50		
1	n D	49.4456	4716.64	+74	4717.38	1	n D	41.7231	4653.51	-53	4652.92	155.38	+2	4652.75	155.38	+2	4652.75	155.38	+2	4652.75		
1	n D	49.3641	4717.99	+74	4718.73	1	n D	41.6742	4654.76	-53	4654.17	157.43	+2	4654.00	157.43	+2	4654.00	157.43	+2	4654.00		
1	n D	49.2826	4719.24	+75	4719.99	1	n D	41.6253	4656.01	-53	4655.42	159.48	+2	4655.25	159.48	+2	4655.25	159.48	+2	4655.25		
1	n D	49.2011	4720.49	+75	4721.24	1	n D	41.5764	4657.26	-53	4656.67	161.53	+2	4656.50	161.53	+2	4656.50	161.53	+2	4656.50		
1	n D	49.1196	4721.74	+76	4722.49	1	n D	41.5275	4658.51	-53	4658.08	163.58	+2	4657.91	163.58	+2	4657.91	163.58	+2	4657.91		
1	n D	49.0381	4723.00	+77	4723.75	1	n D	41.4786	4659.76	-53	4659.33	165.63	+2	4659.16	165.63	+2	4659.16	165.63	+2	4659.16		
1	n D	48.9566	4724.25	+77	4725.00	1	n D	41.4297	4661.01													

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PLATE G 34						PLATE G 32						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
Con. Spec. 2 3 10	from to n B wn D	47.2070 47.0650 47.1801 47.0048	4737.20 4741.30 4737.99 4743.20	+77 -77 +77 +77	4737.97 4742.07 4738.76 4743.97	Con. Spec. 10 Limits	from to B D	38.6130 38.4630 38.5750 38.4079 38.4630 38.3535	4738.30 4742.70 4739.44 4744.34 4742.70 4745.94	-34 -33 -34 -33 -33 -33	4737.96 4742.37 4739.10 4744.01 4742.37 4745.61	37.97 42.22 38.93 43.99 42.17 45.41	+2 +2 +2 +2 +2 +2	4738.0 4742.2 4738.95 4744.01 4742.2 4745.4
B Max	Head from B	46.9490 46.9490 46.9200	4744.80 4744.80 4745.72	+78 -78 +78	4745.58 4745.58 4746.50		Head	38.3535 38.3535 38.3535	4745.94 4745.94 4745.94	-33 -33 -33	4745.61 4745.61 4745.61	45.41 45.78 46.70	+2 +2 +2	4745.43 4745.8 4746.72
2-3	to n D	46.5340 46.5063 46.2660	4757.30 4758.16 4765.40	+80 -80 -81	4758.10 4758.96 4766.21		wn D	37.9029 37.6422 37.4554	4759.31 4767.15 4772.80	-31 -30 -29	4759.00 4766.85 4772.51	58.30 66.53 72.68	+2 +2 +2	4759.00 4766.55 4772.70
1-2 Max	nn D B	46.0522 46.9850 46.0190	4772.04 4774.10 4773.00	+81 -81 -81	4772.85 4774.91 4773.81	1 2	n B	37.4554 37.3635	4772.80 4775.60	-29 -29	4772.51 4775.31	72.68 75.11	+2 +2	4772.70 4775.13
Limits	wn D	45.6792 45.5138 45.3270	4783.60 4788.78 4794.65	+82 -82 +82	4784.42 4789.60 4795.47	2 1	n D	37.0603 36.8884 36.7042	4784.89 4790.19 4795.92	-28 -27 -27	4784.61 4789.92 4795.65	84.52 89.76 95.56	+2 +2 +2	4784.54 4789.78 4795.58
1 Max	n D B	45.3270 44.9803	4794.65 4805.68	+82 +82	4795.47 4806.50	Max 2 1	B B	36.4873 36.3357 36.2005	4802.71 4807.48 4811.77	-26 -25 -25	4802.45 4807.23 4811.52	92.25 96.87 11.32	+2 +2 +2	4802.27 4806.89 4811.34
2-3	nn D	44.8111 44.6939	4811.11 4814.89	+82 -82	4811.93 4815.71	3	wn D	36.1672 36.0481	4812.83 4816.62	-25 -25	4812.58 4816.37	12.26 16.04	+2 +2	4812.28 4816.06
B	from to	44.6730 44.4730	4815.50 4822.00	+82 -81	4816.32 4822.81	B	from to	36.0130 35.9170	4817.70 4820.80	-25 -25	4817.45 4820.55	16.89 21.68	+2 +2	4816.9 4821.7
Max 2	B	44.6003 44.4450	4817.92 4822.98	+82 -81	4818.74 4823.79	Max 4	B	35.9170 35.8040	4820.80 4824.45	-25 -25	4819.83 4824.20	19.29 24.00	+2 +2	4819.31 4824.02
1-2	nn D	44.3181 44.2406	4827.13 4829.67	+81 -81	4827.94 4830.48	3 4	n B	35.7335 35.6665	4826.72 4828.89	-25 -25	4826.47 4828.64	26.27 28.29	+2 +2	4826.29 4828.31
3	wn B D	44.1856	4831.48	+81	4832.29	4 6	B B	35.5994 35.5345	4831.06 4833.12	-25 -25	4830.81 4832.87	30.64 32.59	+2 +2	4830.66 4832.61
1	nn D	43.5980	4851.04	+78	4851.82	1 2	nn B	35.1417 34.9891	4846.02 4851.07	-25 -25	4845.77 4850.82	45.57 50.62	+2 +2	4845.59 4850.64
1-2	nn D	43.4935	4854.57	+78	4855.35	1 2	n D	34.9514 34.8315	4852.32 4856.31	-25 -25	4852.07 4856.06	51.95 55.71	+2 +2	4851.97 4855.73
1	nn D	43.1985	4864.59	+76	4865.35	2 1	n B	34.7751 34.7088	4858.19 4860.42	-25 -25	4857.94 4860.17	57.74 59.97	+2 +2	4857.76 4859.99
1-2	B	43.0744	4868.84	+76	4869.60	2 2	nn B	34.6651 34.5475	4861.88 4865.83	-25 -26	4861.63 4865.57	61.43 65.46	+2 +2	4861.45 4865.48
2	n D	43.0238	4870.58	+75	4871.33	3 4	n D	34.3641	4872.03	-26	4871.77	69.80	+2	4871.57
1-2	n B	42.9047	4874.68	+74	4875.42	1 2	n D	34.2493	4875.93	-27	4875.66	71.55	+2	4875.56
1-2	n B	42.7844	4878.85	+74	4879.59	3	D	34.0713	4882.02	-27	4881.75	75.54	+2	4879.81
3	n D	42.7254	4880.89	+73	4881.62							79.79	+2	4881.71
1	n B	42.6705	4882.81	+73	4883.54							83.74	+2	4883.76
nn D		42.5963	4885.39	+73	4886.12							86.32	+2	4886.34
nn D		42.4570	4890.20	+72	4890.92							91.12	+2	4891.14
1	nn D	42.1798	4900.06	+69	4900.75	3	nn B	33.5729	4899.27	-29	4898.98	98.78	+2	4898.80
2-3	n D	41.6290	4919.82	+66	4920.48		nn D	33.4900	4902.17	-29	4901.88	01.32	+2	4901.34
1	n D	41.4997	4924.52	+65	4925.17		nn D	32.9357	4921.79	-32	4921.47	20.98	+2	4921.00
nn D		41.2530	4933.50	+63	4934.13	1	n D	32.5875	4934.33	-34	4933.99	25.37	+2	4925.39
nn D		40.6280	4956.80	+58	4957.38							33.79	+2	4933.81
												57.58	+2	4957.60

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PLATE G 383					PLATE G 384					MEAN WAVE-LENGTH				
1885 M. 10.6 M.T. 1885. Hour-angle, W 29					1885, February 9 G.M.T. 1884. Hour-angle, W 29					Star good; comparison good				
	Char-acter	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length		Char-acter	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Uncor. rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	μm.	μm.				mm.	μm.	μm.	μm.	μm.	μm.	μm.
4	n D	48.4927	5173.43	-47	5172.96	2	nn D	47.8443	5164.72	-42	5164.30	64.24	+2	5164.26
1	n D	48.2176	5184.30	-52	5183.78		n D	47.6688	5174.04	-44	5173.60	73.28	+2	5173.30
1	n D	48.0836	5189.63	-54	5189.09		n D	47.3500	5184.50	-45	5184.05	83.92	+2	5183.94
3	n D	47.0884	5193.44	-56	5192.88		wn D	47.1157	5193.96	-47	5193.49	89.15	+2	5189.17
2	n D	47.6671	5206.38	-62	5205.76		wn D	46.7480	5209.00	-48	5208.52	93.19	+2	5193.21
												95.82	+2	5195.84
2	nn B	47.4922	5214.80	-66	5214.14		wn D	46.5500	5217.20	-48	5216.72	106.66	+2	5216.68
1 2	n D	47.4082	5217.26	-67	5216.59	1	n D	46.3139	5227.08	-49	5226.59	116.66	+2	5226.35
9	wn D	47.1080	5226.76	-70	5226.06		wn D	46.1290	5234.90	-49	5234.41	126.66	+2	5234.97
6	n D	46.9888	5234.23	-74	5233.49	1	nn D	46.1290	5234.90	-49	5234.41	136.66	+2	5234.97
6	n D	46.6577	5248.07	-79	5247.28	4	n D	45.8192	5248.03	-49	5247.54	146.66	+2	5247.43
1	wn D	46.5657	5251.95	-80	5251.15	2	nn D	45.7209	5252.24	-49	5251.75	156.66	+2	5251.47
1	n D	46.4792	5255.99	-82	5255.17							166.66	+2	5255.35
3	n D	46.1146	5271.17	-86	5270.31	3	n D	48.2825	5271.23	-48	5270.75	176.66	+2	5270.55
2	n D	45.8093	5280.56	-89	5279.67		nn D	45.0008	5283.60	-47	5283.13	186.66	+2	5283.43
1	n D	45.8049	5284.50	-92	5283.62		wn D	44.6710	5298.26	-47	5297.79	196.66	+2	5297.63
2	n D	45.4849	5298.34	-92	5297.47							206.66	+2	5297.63
2	n D	45.3846	5302.98	-92	5302.06							216.66	+2	5302.14
3	n B	45.3227	5305.72	-93	5304.79	1 2	n B	44.5083	5305.56	-46	5305.10	226.66	+2	5304.97
1	nn D	45.2647	5308.29	-93	5307.36							236.66	+2	5307.44
3	n B	45.1980	5313.93	-93	5313.00	2	n B	44.3315	5313.55	-46	5313.09	246.66	+2	5313.07
3	n D	45.0651	5315.85	-93	5314.92		n D	44.2847	5315.08	-46	5315.22	256.66	+2	5315.09
6	n B	45.0411	5318.26	-93	5317.33	2 3	n B	44.2285	5318.24	-45	5317.79	266.66	+2	5317.58
												276.66	+2	5320.19
5	n D	44.9731	5321.04	-93	5320.11	1 2	nn D	43.9740	5329.80	-44	5329.45	286.66	+2	5329.40
2	nn D	44.7933	5329.42	-92	5328.50	2 3	n B	43.8491	5335.05	-44	5335.21	34.88	+2	5334.90
2	nn D	44.6337	5335.45	-91	5334.54	1	n D	43.8101	5337.45	-44	5337.01	36.84	+2	5336.86
2	nn D	44.6137	5337.57	-91	5336.66	2 3	n B	43.7622	5339.67	-43	5339.24	39.10	+2	5339.12
2	nn D	44.5633	5339.86	-90	5338.96	1 2	n D	43.6452	5342.26	-43	5341.83	41.57	+2	5341.59
2	n D	44.5122	5342.20	-90	5341.30	1	nn D	43.5452	5345.11	-43	5344.68	44.62	+2	5344.64
2 3	n D	44.3313	5349.50	-86	5348.64	1	wn D	43.4547	5349.88	-42	5349.46	49.55	+2	5349.57
							n B	43.4833	5352.69	-42	5352.27	52.21	+2	5352.23
3	n B	43.9718	5367.15	-79	5366.39	1	n D	43.1809	5366.98	-40	5366.58	66.49	+2	5366.51
6	n B	43.9193	5369.63	-78	5368.85							68.91	+2	5368.93
7	B	43.8618	5372.33	-76	5371.57	5 6	n D	43.0726	5372.14	-39	5371.75	71.66	+2	5371.68
2	n D	43.7807	5375.82	-74	5375.08	2	n B	43.0051	5375.36	-39	5374.97	75.03	+2	5375.06
2	n D	43.7400	5378.02	-73	5377.30	2	n D	42.9539	5377.82	-39	5377.43	77.36	+2	5377.38
9	wn B	43.6727	5381.24	-70	5380.54	2	wn B	42.8094	5380.73	-38	5380.35	80.45	+2	5380.47
												84.85	+2	5384.87
2	nn D	43.5840	5385.44	-65	5384.79	1	nn D	42.6847	5390.81	-37	5390.44	90.38	+2	5390.40
2	nn D	43.4232	5397.40	-59	5396.81	6 8	wn D	42.5608	5397.32	-36	5396.96	96.89	+2	5396.96
1	n D	43.0561	5409.76	-52	5410.24		nn D	42.2807	5410.08	-35	5409.73	99.99	+2	5410.01
7 8	n D	42.9725	5414.82	-50	5414.32							114.38	+2	5414.40
3	n B	42.9139	5417.67	-48	5417.19	2 3	n B	42.1373	5417.66	-34	5417.32	17.26	+2	5417.28
3	n D	42.8116	5421.20	-46	5420.74	3	n D	42.0780	5420.61	-34	5420.27	20.51	+2	5420.53
2	n D	42.7608	5423.50	-45	5423.06							23.11	+2	5423.13
2	n D	42.6988	5430.67	-42	5430.25	2 3	n D	41.8787	5430.57	-33	5430.24	30.25	+2	5430.27
2	n D	42.6044	5434.89	-40	5434.49							34.55	+2	5434.57
	from	42.4610	5440.00	-38	5439.62							39.68	+2	5439.70
B						Max	B	41.6340	5442.90	-32	5442.58	42.52	+2	5442.54
to												46.00	+2	5446.04
9	n D	42.2944	5448.25	-35	5447.90	8	n D	41.5415	5447.62	-32	5447.30	47.60	+2	5447.62
Max	B	42.2008	5453.54	-34	5451.00		from	41.5070	5449.36	-32	5449.04	48.98	+2	5449.04
												51.06	+2	5451.08
1 2	n D	41.1175	5457.11	-32	5456.82		to	41.3880	5455.44	-31	5455.13	55.07	+2	5455.11
1 2	n D	41.0300	5461.05	-31	5461.05		n D	41.3565	5457.07	-31	5456.76	56.79	+2	5456.81
2	n D	41.8892	5468.04	-30	5468.20		n D	41.2772	5461.14	-31	5460.83	60.94	+2	5460.96
2	n B	41.8684	5472.84	-29	5472.55		wn D	41.1319	5468.65	-30	5468.35	68.28	+2	5468.30
												72.61	+2	5472.63
1	n D	41.5984	5483.47	-27	5483.30		n D	41.0135	5474.80	-30	5474.50	74.44	+2	5474.46
												78.23	+2	5478.25
3 4	n D	41.3907	5488.60	-25	5488.44		n D	40.9408	5478.59	-30	5478.29	78.23	+2	5483.19
							from	40.8608	5483.33	-30	5483.03	83.17	+2	5486.84
												86.75	+2	5490.22
												98.20	+2	5498.22
							to	40.5990	5504.20	-29	5503.91	93.85	+2	5503.91

78 SCHJELLERUP *Continued*

PLATE G 390					PLATE G 384					MEAN WAVE-LENGTH					
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	
		mm.	t.m.		t.m.			mm.	t.m.		t.m.			t.m.	
3	n B	41.0955	5509.74	-23	5509.51	...	...	...	...	...	...	09.57	+2	5509.59	
3	n D	41.0122	5512.55	-23	5512.32	...	nn D	40.2948	5512.81	-29	5512.52	12.42	+2	5512.45	
1-2	nn D	40.7906	5525.56	-22	5525.34	...	wn D	40.0551	5525.80	-28	5525.52	25.43	+2	5525.45	
1	nn D	40.6240	5534.76	-22	5534.54	...	...	...	...	...	...	34.60	+2	5534.62	
8	w D	40.5270	5540.00	-22	5539.78	1	B	39.8639	5536.17	-28	5535.89	35.83	+2	5535.85	
B	from	40.4820	5542.40	-22	5542.18	6 8	D	39.8020	5539.56	-28	5539.28	39.53	+2	5539.55	
2	to	40.3890	5547.50	-22	5547.28	...	to	39.7530	5542.30	-28	5542.02	42.10	+2	5542.1	
1	n D	40.3678	5548.61	-22	5548.39	1	n D	39.6299	5547.60	-28	5547.32	47.30	+2	5547.3	
1	n D	40.2939	5552.02	-22	5552.40	0 1	nn D	39.5635	5549.05	-28	5548.77	48.58	+2	5548.60	
1	n D	40.2238	5556.44	-22	5556.22	0-1	nn D	39.4905	5552.73	-28	5552.45	52.43	+2	5552.45	
1-2	n D	40.1000	5563.20	-22	5562.98	0-1	nn D	39.4905	5556.78	-28	5556.50	56.36	+2	5556.38	
1	n D	40.0241	5567.39	-22	5567.17	1	nn D	39.3853	5562.65	-28	5562.37	62.68	+2	5562.70	
1	n D	39.9680	5570.50	-22	5570.28	...	...	39.2985	5567.52	-28	5567.24	67.21	+2	5567.23	
1	n D	39.8936	5574.59	-22	5574.37	...	from	39.1860	5573.90	-28	5573.62	70.34	+2	5570.36	
Max	D	39.7204	5584.21	-22	5583.99	D	D	39.0016	5584.29	-28	5584.01	73.56	+2	5573.6	
Head	B	39.6840	5586.22	-22	5586.00	Head	to	38.9680	5586.20	-28	5585.92	74.43	+2	5574.45	
3	n B	39.6628	5587.43	-22	5587.21	3	B	38.9670	5586.30	-28	5586.02	84.00	+2	5584.02	
1	nn D	39.6240	5589.61	-22	5589.39	3	n D	38.9456	5587.48	-28	5587.20	85.84	+2	5585.9	
2 3	n B	39.5700	5592.63	-23	5592.40	3	n B	38.9122	5589.38	-28	5589.10	86.01	+2	5586.03	
2	n D	39.5227	5595.29	-23	5595.06	2	n B	38.8661	5592.03	-28	5591.75	87.21	+2	5587.23	
4	B	39.4770	5597.87	-23	5597.64	3	n B	38.8111	5595.18	-28	5594.90	89.25	+2	5589.27	
1	nn D	39.4206	5601.05	-24	5600.81	1-2	nn D	38.7651	5597.82	-28	5597.54	92.08	+2	5592.10	
D	from	39.3020	5607.80	-24	5607.56	...	...	38.7239	5600.19	-28	5599.91	94.96	+2	5594.98	
...	to	39.2230	5612.30	-24	5612.06	...	nn D	38.5591	5609.72	-28	5609.44	97.59	+2	5597.61	
...	from	39.1080	5618.80	-25	5618.55	...	...	...	...	...	...	100.36	+2	5600.38	
Max	D	38.9800	5625.60	-25	5625.35	2	n D	38.3739	5620.51	-28	5620.23	07.62	+2	5607.6	
Max	D	38.9600	5627.30	-26	5627.04	...	nn D	38.2854	5625.70	-28	5625.42	09.50	+2	5609.52	
8	D	38.8405	5634.26	-26	5634.00	10	D	38.1328	5634.70	-28	5634.42	12.12	+2	5612.1	
Head	from	38.7964	5636.81	-26	5636.55	Head	...	38.0896	5637.26	-28	5636.98	18.61	+2	5618.6	
...	n B	38.7658	5638.60	-27	5638.33	...	B	38.0571	5639.19	-28	5638.91	20.16	+2	5620.18	
B	n B	38.7102	5641.84	-27	5641.57	...	B	38.0102	5641.97	-29	5641.68	25.36	+2	5625.38	
8	to	38.6850	5642.70	-27	5642.43	...	...	...	...	...	...	27.10	+2	5627.1	
2	nn D	38.6625	5644.62	-28	5644.34	1	n D	37.9680	5644.49	-29	5644.20	34.21	+2	5634.23	
1	nn D	38.5603	5650.61	-28	5650.33	1	nn D	37.8694	5650.39	-29	5650.10	36.77	+2	5636.79	
...	nn B	38.5130	5653.40	-28	5653.12	...	...	...	...	...	...	36.77	+2	5636.8	
...	nn D	38.4306	5658.25	-29	5657.96	2	n B	37.7830	5655.57	-29	5655.28	38.62	+2	5638.64	
3	nn D	38.2088	5671.35	-31	5671.04	1	n D	37.7503	5657.54	-29	5657.25	41.63	+2	5641.65	
2	nn B	38.1633	5674.13	-32	5673.81	1-2	n B	37.5132	5671.89	-30	5671.59	42.49	+2	5642.5	
1-2	nn D	38.1202	5676.70	-32	5676.38	2	n D	37.4736	5674.31	-30	5674.01	44.27	+2	5644.29	
2	n B	38.0704	5679.69	-32	5679.37	...	...	37.4327	5676.81	-30	5676.51	50.22	+2	5650.24	
1-2	n B	37.9977	5684.06	-33	5683.73	...	...	...	...	...	...	53.18	+2	5653.2	
8	wn B	37.8353	5693.88	-34	5693.54	6	n B	37.1484	5694.30	-31	5693.99	55.22	+2	5655.24	
1	nn D	37.7910	5696.60	-35	5696.25	...	...	...	...	...	...	57.61	+2	5657.63	
4	n B	37.6508	5705.12	-36	5704.76	5	n B	36.9668	5705.60	-31	5705.29	71.32	+2	5671.34	
3-4	n D	37.6018	5708.12	-37	5707.75	2	n D	36.9191	5708.58	-31	5708.27	73.91	+2	5673.93	
1	n D	37.5210	5713.10	-37	5712.73	1	n D	36.8338	5713.93	-32	5713.61	76.45	+2	5676.47	
6	wn B	37.4514	5717.37	-38	5716.99	8	wn B	36.7734	5717.74	-32	5717.42	79.43	+2	5679.45	
1	n D	37.3829	5721.61	-39	5721.22	2	n D	36.7063	5721.97	-32	5721.65	83.79	+2	5683.81	
6	wn B	37.3330	5724.70	-39	5724.31	6	wn B	36.6566	5725.12	-32	5724.80	93.77	+2	5693.79	
3-4	n D	37.2257	5731.38	-40	5730.98	8	wn D	36.5441	5732.27	-33	5731.94	96.31	+2	5696.33	
...	...	...	...	...	...	...	from	36.3830	5742.60	-33	5742.27	101.22	+2	5705.05	
3	n D	37.0343	5743.37	-43	5742.94	0	...	...	...	...	...	08.01	+2	5708.03	
2	nn D	36.9297	5750.00	-44	5749.56	D	1	n D	36.2611	5750.44	-34	5750.10	13.17	+2	5713.19
3	nn D	36.7301	5762.66	-46	5762.20	1	n D	36.2490	5751.20	-34	5750.86	17.21	+2	5717.23	
3	nn D	36.6045	5770.70	-48	5770.22	3	n D	36.0743	5762.56	-35	5762.21	21.44	+2	5721.46	
...	...	...	...	...	...	...	...	...	...	...	...	24.56	+2	5724.58	
...	...	...	...	...	...	...	...	...	...	...	...	31.46	+2	5731.48	
...	...	...	...	...	...	...	...	...	...	...	...	42.21	+2	5742.2	
...	...	...	...	...	...	...	...	...	...	...	...	43.00	+2	5743.02	
...	...	...	...	...	...	...	...	...	...	...	...	49.83	+2	5749.85	
...	...	...	...	...	...	...	...	...	...	...	...	50.80	+2	5750.8	
...	...	...	...	...	...	...	...	...	...	...	...	62.21	+2	5762.23	
...	...	...	...	...	...	...	...	...	...	...	...	70.69	+2	5770.71	

## 78 SCHJELLERUP—Continued

PLATE G 384					PLATE G 384					MEAN WAVE LENGTH			
Inten-	Char-	Mean	Wave	Wave	Inten-	Char-	Mean	Wave	Cor.	Wave	Uncor-	Cor.	
city	acter	Scale	Length	from	city	acter	Scale	Length	from	Length	rected for	rected for	
			t.m.	t.m.			mm.	t.m.		t.m.	Velocity	Velocity	
		36.5740	5772.30	-50	5771.80					71.86	+2	5771.9	
		36.5740	5780.30	-50	5780.40					80.46	+2	5780.5	
		36.5740	5786.30	-50	5785.80	3	wd D	35.7232	5785.63	-36	5785.27	+2	5785.23
1	n D	36.3405	5790.36	-51	5789.85	...				85.86	+2	5789.9	
1	n D	36.1827	5798.05	-52	5797.53	...				89.91	+2	5789.43	
1	n D	36.0953	5811.75	-53	5803.26	1-2	n D	35.4446	5804.24	-38	5803.86	+2	5797.61
1	n D	35.8883	5822.80	-60	5822.20	1	nn D	35.1549	5823.87	0	5823.48	+2	5803.58
1	n D	35.3991	5850.34	-60	5849.74					22.84	+2	5822.86	
										49.80	+2	5849.82	

## 132 SCHJELLERUP = U HYDRAE

PLATE G 385					PLATE G 388					MEAN WAVE LENGTH			
1899, March 23, G.M.T. 18.45 Bright night, W. 1-1.4 Star excellent; comparison fair					1899, December 29, G.M.T. 22.41 Bright night, W. 1-1.4 Star fair; comparison fair								
Intensity	Character	Mean Scale Reading	Wave Length in Airy Unit	Wave Length in Airy Unit	Intensity	Character	Mean Scale Reading	Wave Length in Airy Unit	Wave Length in Airy Unit	Correction for Velocity	Correction for Velocity		
		mm.	t.m.	t.m.			mm.	t.m.	t.m.	t.m.	t.m.		
Spec begins		36.5740	5772.30	-50	5771.80					96.2	+0	4286.6	
		36.5740	5780.30	-50	5780.40					11	+1	4374	
		36.5740	5786.30	-50	5785.80	3	wd D	35.7232	5785.63	-36	5785.27	+2	4375.9
1	n D	36.3405	5790.30	-51	5789.85					21.0	+1	4381.4	
1	n D	36.1827	5798.05	-52	5797.53					84.8	+1	4385.2	
1	n D	36.0953	5811.75	-53	5803.26	1-2	n D	35.4446	5804.24	-38	5803.86	+2	4388.7
1	n D	35.8883	5822.80	-60	5822.20	1	nn D	35.1549	5823.87	0	5823.48	+2	4389.7
1	n D	35.3991	5850.34	-60	5849.74					92.43	+1	4391.84	
1	n D	35.1100	5866.30	-60	5865.70					94.06	+1	4395.07	
1	n D	34.8209	5882.30	-60	5881.70					85.85	+1	4395.76	
1	n D	34.5318	5898.30	-60	5897.70					97.49	+1	4397.90	
1	n D	34.2427	5914.30	-60	5913.70					94.85	+1	4398.24	
1	n D	33.9536	5930.30	-60	5929.70					92.29	+1	4399.59	
1	n D	33.6645	5946.30	-60	5945.70					90.73	+1	4400.93	
1	n D	33.3754	5962.30	-60	5961.70					88.17	+1	4402.27	
1	n D	33.0863	5978.30	-60	5977.70					85.61	+1	4403.61	
1	n D	32.7972	5994.30	-60	5993.70					83.05	+1	4404.95	
1	n D	32.5081	6010.30	-60	6009.70					80.49	+1	4406.29	
1	n D	32.2190	6026.30	-60	6025.70					77.93	+1	4407.63	
1	n D	31.9299	6042.30	-60	6041.70					75.37	+1	4408.97	
1	n D	31.6408	6058.30	-60	6057.70					72.81	+1	4410.31	
1	n D	31.3517	6074.30	-60	6073.70					70.25	+1	4411.65	
1	n D	31.0626	6090.30	-60	6089.70					67.69	+1	4412.99	
1	n D	30.7735	6106.30	-60	6105.70					65.13	+1	4414.33	
1	n D	30.4844	6122.30	-60	6121.70					62.57	+1	4415.67	
1	n D	30.1953	6138.30	-60	6137.70					60.01	+1	4417.01	
1	n D	29.9062	6154.30	-60	6153.70					57.45	+1	4418.35	
1	n D	29.6171	6170.30	-60	6169.70					54.89	+1	4419.69	
1	n D	29.3280	6186.30	-60	6185.70					52.33	+1	4421.03	
1	n D	29.0389	6202.30	-60	6201.70					49.77	+1	4422.37	
1	n D	28.7498	6218.30	-60	6217.70					47.21	+1	4423.71	
1	n D	28.4607	6234.30	-60	6233.70					44.65	+1	4425.05	
1	n D	28.1716	6250.30	-60	6249.70					42.09	+1	4426.39	
1	n D	27.8825	6266.30	-60	6265.70					39.53	+1	4427.73	
1	n D	27.5934	6282.30	-60	6281.70					36.97	+1	4429.07	
1	n D	27.3043	6298.30	-60	6297.70					34.41	+1	4430.41	
1	n D	27.0152	6314.30	-60	6313.70					31.85	+1	4431.75	
1	n D	26.7261	6330.30	-60	6329.70					29.29	+1	4433.09	
1	n D	26.4370	6346.30	-60	6345.70					26.73	+1	4434.43	
1	n D	26.1479	6362.30	-60	6361.70					24.17	+1	4435.77	
1	n D	25.8588	6378.30	-60	6377.70					21.61	+1	4437.11	
1	n D	25.5697	6394.30	-60	6393.70					19.05	+1	4438.45	
1	n D	25.2806	6410.30	-60	6409.70					16.49	+1	4439.79	
1	n D	24.9915	6426.30	-60	6425.70					13.93	+1	4441.13	
1	n D	24.7024	6442.30	-60	6441.70					11.37	+1	4442.47	
1	n D	24.4133	6458.30	-60	6457.70					8.81	+1	4443.81	
1	n D	24.1242	6474.30	-60	6473.70					6.25	+1	4445.15	
1	n D	23.8351	6490.30	-60	6489.70					3.69	+1	4446.49	
1	n D	23.5460	6506.30	-60	6505.70					1.13	+1	4447.83	
1	n D	23.2569	6522.30	-60	6521.70								
1	n D	22.9678	6538.30	-60	6537.70								
1	n D	22.6787	6554.30	-60	6553.70								
1	n D	22.3896	6570.30	-60	6569.70								
1	n D	22.1005	6586.30	-60	6585.70								
1	n D	21.8114	6602.30	-60	6601.70								
1	n D	21.5223	6618.30	-60	6617.70								
1	n D	21.2332	6634.30	-60	6633.70								
1	n D	20.9441	6650.30	-60	6649.70								
1	n D	20.6550	6666.30	-60	6665.70								
1	n D	20.3659	6682.30	-60	6681.70								
1	n D	20.0768	6698.30	-60	6697.70								
1	n D	19.7877	6714.30	-60	6713.70								
1	n D	19.4986	6730.30	-60	6729.70								
1	n D	19.2095	6746.30	-60	6745.70								
1	n D	18.9204	6762.30	-60	6761.70								
1	n D	18.6313	6778.30	-60	6777.70								
1	n D	18.3422	6794.30	-60	6793.70								
1	n D	18.0531	6810.30	-60	6809.70								
1	n D	17.7640	6826.30	-60	6825.70								
1	n D	17.4749	6842.30	-60	6841.70								
1	n D	17.1858	6858.30	-60	6857.70								
1	n D	16.8967	6874.30	-60	6873.70								
1	n D	16.6076	6890.30	-60	6889.70								
1	n D	16.3185	6906.30	-60	6905.70								
1	n D	16.0294	6922.30	-60	6921.70								
1	n D	15.7403	6938.30	-60	6937.70								
1	n D	15.4512	6954.30	-60	6953.70								
1	n D	15.1621	6970.30	-60	6969.70								
1	n D	14.8730	6986.30	-60	6985.70								
1	n D	14.5839	7002.30	-60	7001.70								
1	n D	14.2948	7018.30	-60	7017.70								
1	n D	14.0057	7034.30	-60	7033.70								
1	n D	13.7166	7050.30	-60	7049.70								
1	n D	13.4275	7066.30	-60	7065.70								
1	n D	13.1384	7082.30	-60	7081.70								
1	n D	12.8493	7098.30	-60	7097.70								
1	n D	12.5602	7114.30	-60	7113.70								
1	n D	12.2711	7130.30	-60	7129.70								
1	n D	11.9820	7146.30	-60	7145.70								
1	n D	11.6929	7162.30	-60	7161.70								
1	n D	11.4038	7178.30	-60	7177.70								
1	n D	11.1147	7194.30	-60	7193.70								
1	n D	10.8256	7210.30	-60	7209.70								
1	n D	10.5365	7226.30	-60	7225.70								
1	n D	10.2474	7242.30	-60	7241.70								
1	n D	9.9583	7258.30	-60	7257.70								
1	n D	9.6692	7274.30	-60	7273.70								
1	n D	9.3801	7290.30	-60	7289.70								
1	n D	9.0910	7306.30	-60	7305.70								
1	n D	8.8019	7322.30	-60	7321.70								
1	n D	8.5128	7338.30	-60	7337.70								
1	n D	8.2237	7354.30	-60	7353.70								
1	n D	7.9346	7370.30	-60	7369.70								
1	n D	7.6455	7386.30	-60	7385.70								
1	n D	7.3564	7402.30	-60	7401.70								
1	n D	7.0673	7418.30	-60	7417.70								
1	n D	6.7782	7434.30	-60	7433.70								
1	n D	6.4891	7450.30	-60	7449.70								
1	n D	6.1999	7466.30	-60	7465.70								
1	n D	5.9108	7482.30	-60	7481.70								
1	n D	5.6217	7498.30	-60	7497.70								
1	n D	5.3326	7514.30	-60	7513.70								
1	n D	5.0435	7530.30	-60	7529.70								
1	n D	4.7544	7546.30	-60	7545.70								
1	n D	4.4653	7562.30	-60	7561.70								
1	n D	4.1762	7578.30	-60	7577.70								
1	n D	3.8871	7594.30	-60	7593.70								
1	n D	3.5980	7610.30	-60	7609.70								
1	n D	3.3089	7626.30	-60	7625.70								
1	n D	3.0198	7642.30	-60	7641.70								
1	n D	2.7307	7658.30	-60	7657.70								
1	n D	2.4416	7674.30	-60	7673.70								
1	n D	2.1525	7690.30	-60	7689.70								
1	n D	1.8634	7706.30	-60	7705.70								
1	n D	1.5743	7722.30	-60	7721.70								
1	n D	1.2852	7738.30	-60	7737.70								
1	n D	0.9961	7754.30	-60	7753.70								
1	n D	0.7070	7770.30	-60	7769.70								
1	n D	0.4179	7786.30	-60	7785.70								
1	n D	0.128											





132 SCHJELLERUP—Continued

PLATE A 328					PLATE G 309					PLATE G 368					MEAN WAVE-LENGTH					
In- ten- sity	Char- acter	Mean	Wave-	Wave- Length	In- ten- sity	Char- acter	Mean	Wave-	Wave- Length	In- ten- sity	Char- acter	Mean	Wave-	Wave- Length	Uncor- rected Velocity	Cor- rected V	Cor- rected for Velocity			
		Scale Read- ing	Length by For- mula				Scale Read- ing	Length by For- mula				Scale Read- ing	Length by For- mula							
		mm.	t.m.	t.m.			mm.	t.m.	t.m.			mm.	t.m.	t.m.	t.m.	t.m.	t.m.			
3	D	50.5872	4665.41	+24	4665.65										65.65	+44	4666.09			
2 3	n D	50.6873	4667.19	-21	4667.43										67.43	+44	4667.87			
2	nn D	51.5407	4681.83	-38	4682.11										82.11	+44	4682.55			
	nn B	51.8997	4688.04	-30	4688.34										88.34	+44	4688.78			
1	nn B	51.9397	4689.09	-30	4689.29										89.39	+44	4689.83			
1	B	52.5344	4699.53	-32	4699.85										99.85	+44	4700.29			
1	B	52.4980	4700.47	-32	4700.79										100.79	+44	4701.23			
1	n D	52.6500	4701.22	-32	4701.54										01.54	+44	4701.98			
1-2	n D	52.6903	4701.93	-32	4702.25										02.25	+44	4702.69			
1	n D	52.7540	4703.06	-32	4703.38										03.38	+44	4703.82			
1	n D	52.8505	4704.77	-32	4705.09										05.09	+44	4705.53			
2	n B	52.8925	4705.52	-32	4705.84										05.81	+44	4706.28			
2 3	B	53.0759	4708.77	-33	4709.10	1	B	49.0844	47.0949	+3	4709.52				09.31	+44	4709.55			
	wn D	53.1788	4711.78	+33	4715.11										10.99	+44	4711.44			
															15.11	+44	4715.55			
3	B	53.4762	4715.97	-34	4716.31										15.80	+44	4716.24			
3	D	53.5117	4716.66	-34	4717.00										16.31	+44	4716.75			
3	B	53.5277	4717.33	-34	4717.69										17.00	+44	4717.44			
3	D	53.5919	4718.06	-34	4718.40										17.69	+44	4718.13			
1	B	53.6160	4718.49	-34	4718.83										18.40	+44	4718.84			
	D	53.6327	4719.15	-34	4719.49										18.83	+44	4719.27			
	B	53.6802	4719.81	-34	4720.15										19.49	+44	4719.93			
	wn D	53.8110	4722.02	-34	4722.36	2	n D	48.6381	47.2201	+6	47.2.10				20.15	+44	4720.23			
Con. Spec.	to	53.8499	4722.66	-34	4723.00										22.23	+44	4722.67			
	w D	54.0700	4726.90	-35	4727.25										23.00	+44	4723.44			
2	n D	54.2185	4729.15	-36	4729.51										27.25	+44	4727.77			
1	n D	54.2912	4730.83	-36	4731.19										29.81	+44	4730.25			
1	n D	54.3122	4731.71	-36	4732.07										31.19	+44	4731.63			
1	D	54.3738	4733.97	-36	4734.33										32.07	+44	4732.51			
7	B	54.6185	4738.02	-37	4738.39										35.99	+44	4739.43			
4-5	n D	54.7390	4739.03	-37	4739.40										38.35	+44	4738.79			
	n B	54.8032	4740.27	-37	4740.61										39.40	+44	4739.84			
10	D	54.9734	4743.38	-37	4743.75										40.64	+44	4741.08			
	Head	55.0210	4744.26	-37	4744.63										41.26	+44	4742.52			
7	n B	55.0942	4745.55	-37	4745.91										43.56	+44	4744.00			
6	n D	55.1678	4746.82	-37	4747.18										44.77	+44	4745.21			
2-3	n B	55.1952	4747.51	-37	4747.88										45.94	+44	4746.38			
1	n D	55.2522	4748.58	-38	4748.96										46.88	+44	4747.32			
4	n B	55.2975	4749.61	-38	4749.99										47.88	+44	4748.32			
1	n B	55.3588	4751.33	-38	4751.71										48.96	+44	4749.40			
3	n B	55.6065	4755.23	-38	4755.61										49.99	+44	4750.43			
3	n B	55.6527	4756.10	-38	4756.48										54.71	+45	4753.16			
3	n B	55.8185	4759.24	-38	4759.62										55.61	+45	4756.06			
1	n D	55.8707	4760.29	-39	4760.68										60.88	+45	4760.07			
	n B	55.9689	4762.09	-39	4762.48										62.48	+45	4762.93			
	nn D	56.0145	4762.96	-39	4763.35										63.35	+45	4763.78			
2	n D	56.1515	4765.63	-39	4766.02										66.02	+45	4766.47			
	n B	56.3753	4769.86	-39	4770.25										70.25	+45	4770.50			
	nn D	56.4092	4770.50	-39	4770.89										70.89	+46	4771.34			
	nn D	56.4759	4771.79	-39	4772.18										72.32	+45	4772.77			
	n B	56.5880	4773.94	-39	4774.33										74.33	+45	4774.78			
	nn D	57.0685	4783.82	-40	4784.23	1	n D	46.5200	4784.29	+13	4784.42				84.33	+45	4784.78			
2-3	D	57.3350	4788.46	-40	4788.86	1	n D	46.3532	4789.39	+13	4789.52	1	n D	40.1024	4788.63	+66	4789.29	85.25	+45	4789.67
	n D	58.6539	4814.66	-40	4815.06	1-2	n D	45.5132	4815.53	-9	4815.63	1-2	n D	39.5773	4805.16	+69	4805.85	89.85	+45	4806.70
	from	59.1050	4823.82	+40	4824.22	1	n D	45.3391	4823.58	-9	4823.67	1	n D	39.5701	4815.08	+69	4815.77	91.47	+45	4816.36
															82.58	+45	4823.58	21.22	+45	4824.74
2	to	59.2190	4826.20	-40	4826.60										88.26	+45	4829.67	25.60	+45	4829.95
2	nn D	59.2728	4826.84	-40	4827.24	1	n D	45.1254	4827.86	+8	4827.94	1	D	38.8879	4827.36	+69	4828.05	27.74	+45	4828.19
4	B	59.3755	4829.35	+40	4829.75										29.86	+45	4829.31	31.85	+45	4829.30
3	from	59.4685	4831.29	+40	4831.69	3	n D	44.9658	4832.01	-8	4832.09	1	D	38.8822	4829.29	+68	4829.97	32.60	+45	4829.30
	to	59.5120	4832.20	+40	4832.60										38.19	+45	4828.48	38.19	+45	4828.48
1	n D	59.7550	4837.80	-39	4838.19										43.05	+45	4833.30	43.05	+45	4833.30
1 1-5	n D	60.0194	4842.66	-39	4843.05										48.19	+45	4838.45	48.19	+45	4838.45
1	n B	60.3192	4848.92	-39	4849.31										50.45	+45	4843.50	50.45	+45	4843.50
1	n D	60.3977	4850.52	-38	4850.91										55.58	+46	4848.10	55.58	+46	4848.10
	nn D	60.5772	4854.35	-38	4854.73										57.31	+46	4850.65	57.31	+46	4850.65
B	from	60.6150	4855.20	-38	4855.58										58.19	+46	4851.19	58.19	+46	4851.19
	to	60.7540	4858.10	+38	4858.48										58.83	+46	4851.83	58.83	+46	4851.83
1	n D	60.7717	4858.45	-38	4858.83										60.78	+46	4852.78	60.78	+46	4852.78
1	n B	61.1691	4866.91	-37	4867.28										62.98	+46	4854.98	62.98	+46	4854.98
1	n D	61.2467	4868.43	-37	4868.80										64.80	+46	4856.80	64.80	+46	4856.80
2-3	wn D	61.3197	4870.12	-37	4870.49	2	n D	43.8034	4871.20	-1	4871.21	1-2	n D	37.5017	4870.57	+63	4871.20	70.97	+46	4871.43
	n D	61.5232	4874.50	-36	4874.86	2	n D	43.6862	4873.14	0	4873.14	1-2	n D	37.4751	4874.56	+62	4875.18	75.06	+46	4875.52
	wn B	61.7447	4878.64	-35	4878.98										76.28	+46	4879.45	76.28	+46	4879.45
3	D	61.7979	4880.44	+35	4880.79										77.74	+46	4880.68	77.74	+46	4880.68
1	nn D	62.2457	4890.16	-35	4890.49	2	n D	43.2250	4890.83	-1	4890.84	2 3	n D	37.2970	4880.69	+60	4881.29	80.65	+46	4881.03
															81.45	+46	4881.11	81.45	+46	4881.11
2	n D	62.6704	4896.56	-31	4896.87	1-2	n D	42.9421	4900.59	5	4900.54	Max	B	36.8043	4897.86	+78	4898.44	98.44	+46	4898.90
1	n D	63.0839	4908.76	+29	4909.05	1	n D	42.6787	4909.76	-7	4909.69					100.21	+46	4900.67		

## 132 SCHJELLERUP—Continued

PLATE G 28					PLATE G 29					PLATE G 30					MEAN WAVE-LENGTH			
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Form. t.m.	Wave- Length by Form. t.m.	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Form. t.m.	Wave- Length by Form. t.m.	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Form. t.m.	Wave- Length by Form. t.m.	Uncor- rected Velocity	Cor- rected Velocity	Cor- rected Velocity	
		t.m.	t.m.	t.m.			mm.	t.m.	t.m.			mm.	t.m.	t.m.	t.m.	t.m.	t.m.	
D	from	63.5110	4918.35	4918.62	4	wn D	12.5885	4920.15	4920.06						18.62	46	4919.1	
				4921.07											20.06	46	4920.52	
1	D		4923.87	4924.13	1	n D	12.2459	4925.40	4925.00						21.07	46	4921.5	
3	D		4932.78	4933.02	2-3	D	11.4662	4933.93	4933.84	2	n D	35.5881	4933.19	+50	4923.69	33.55	46	4924.01
			Strong continuous spec- trum			D	11.3434	4934.34	4934.28						22.58	46	4925.03	
						D	10.7551	4939.61	4939.41						29.41	47	4929.88	
			4941.15	4941.55											31.55	47	4932.02	
nn D7	65.5020	4980.90	+7	4980.96											39.97	47	4936.14	
		4988.31		4988.38	1	n D	10.2255	4989.75	4989.52						49.95	47	5000.42	
		4998.41		4998.4											65.11	47	5006.61	
		5009.49		5009.49											69.19	47	5009.96	
		5013.87		5013.87											15.87	47	5014.34	
		5036.10		5036.3														
					End		20.5302	5054.00	5053.49	End		36.5880	5049.1	+30	5049.1			

## 132 SCHJELLERUP

PLATE G 299							PLATE G 301							MEAN WAVE-LENGTH		
1899, March 6, G.M.T. 17.55. Hour angle, W 105°.							1899, March 6, G.M.T. 19.00. Hour angle, W 105°.							Star excellent; comparison faint		
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Form. t.m.	Cor- rected Velocity	Wave- Length t.m.		Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula t.m.	Cor- rected Velocity	Wave- Length t.m.	Uncor- rected Velocity	Cor- rected Velocity	Corrected Velocity	
		mm.	t.m.		t.m.				mm.	t.m.		t.m.	t.m.	t.m.	t.m.	
Head		46.5440	5167.70	+13	5167.83	Head			47.1560	5167.10	+17	5167.27	67.55	+49	5168.04	
2	n D	46.4342	5172.02	+11	5172.13	5	n D		47.0198	5172.46	+13	5172.59	72.36	+49	5172.85	
D	from	46.2150	5180.70	+8	5180.78											
	to	46.1120	5184.70	+7	5184.77		wn D		46.7500	5183.10	+7	5183.17	80.68	+49	5181.2	
1	n D	46.0144	5188.77	+7	5188.84	1										
							B									
2	n D	45.9239	5192.41	+6	5192.47	4	n D		46.7040	5184.90	+7	5184.97	84.87	+49	5185.2	
							nn D		46.6120	5188.38	+6	5188.64	88.74	+49	5189.23	
D	from	45.6500	5203.50	+3	5203.53		to		46.5170	5191.20	+6	5191.26	91.36	+49	5191.9	
	to	45.4680	5211.00	+1	5211.01	D	n D		46.4116	5192.57	+5	5192.62	92.55	+49	5193.04	
1	n D	45.3410	5216.05	+1	5216.04		from		46.4840	5193.68	+5	5193.73	93.83	+49	5194.3	
	n D	45.2876	5226.86	+4	5226.79	5	D		46.5500	5203.68	0	5203.68	94.01	+49	5204.1	
2	n D	44.9238	5233.49	+6	5233.43	4	n D		46.0410	5211.54	+3	5211.51	11.31	+49	5211.8	
1	n B	44.8580	5236.30	+7	5236.23	Max	B		45.9298	5216.06	+5	5216.01	16.03	+49	5216.52	
							1	n D	45.6063	5226.88	+9	5226.79	26.79	+49	5227.28	
2 3	n D	44.5993	5247.16	+10	5247.06	3	n D		45.5059	5233.51	+11	5233.40	33.42	+49	5233.91	
2 3	n D	44.5040	5251.20	+12	5251.08	3	D		45.4470	5235.95	+12	5235.83	36.03	+49	5238.52	
							1	n D	45.3657	5236.30	+13	5236.20	39.30	+49	5239.79	
4	n D	44.8806	5270.38	+19	5270.19	5	D		45.1846	5246.92	+15	5246.77	46.92	+49	5247.41	
							1	nn D	45.0872	5251.01	+17	5250.84	50.96	+49	5251.46	
1	nn D	44.8200	5280.71	+21	5280.50	3	D		44.9889	5255.17	+17	5255.00	55.10	+50	5255.01	
3	n D	44.4253	5297.99	+24	5297.75		B		44.8447	5269.82	+20	5269.62	69.91	+50	5270.41	
1	n D	44.4004	5302.20	+25	5301.95	1-2	B		44.4300	5279.07	+21	5278.86	78.96	+50	5279.00	
2	n D	43.9104	5315.16	+27	5314.89											
							1	B	43.6564	5313.01	+18	5312.83	83.40	+50	5283.90	
3	n D	42.9105	5321.01	+29	5320.73	3	D		43.6151	5314.85	+18	5314.67	97.61	+50	5298.11	
3 4	n D	42.7342	5329.00	+29	5328.71	2	B		43.5594	5317.34	+18	5317.16	101.85	+50	5302.35	
1	n D	42.5628	5339.81	+31	5339.52	4	n D		43.5009	5328.55	+15	5328.40	122.93	+50	5313.43	
2 3	n D	42.4548	5341.75	+31	5341.47	1	nn D		43.1490	5335.84	+13	5335.71	126.61	+50	5318.28	
						2	n D		43.0578	5340.00	+11	5340.79	130.61	+50	5317.76	
1	n D	41.9661	5362.90	+31	5362.60	1	B		42.7090	5352.00	+8	5351.92	142.41	+50	5329.06	
2	n D	41.9202	5366.00	+31	5365.70	1	nn D		42.4805	5366.20	+6	5366.14	145.36	+50	5332.13	
2	B	41.8809	5369.10	+31	5368.79	2	B		42.4432	5368.36	+5	5368.31	148.31	+50	5336.82	
5	D	41.8414	5371.71	+31	5371.40	10	D		42.3777	5371.42	+5	5371.37	151.26	+50	5339.05	

## 132 SCHJELLERUP—Continued

PLATE G 289						PLATE G 301						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	μm.		μm.			mm.	μm.		μm.	μm.		μm.
3	n B	41.7105	5375.06	-31	5374.75	6	B	42.3104	5374.59	-4	5374.55	74.65	+50	5375.15
1	n D	41.6927	5377.32	-31	5377.01	1	n D	42.2612	5376.90	-4	5376.86	76.94	+50	5377.44
n	n B	41.6281	5380.38	-32	5380.06							79.96	+50	5380.46
1	n D	41.5478	5484.20	-32	5383.88	1	n D	42.1056	5384.25	-3	5384.22	84.05	+50	5384.55
						1	nn D	41.8301	5397.38	-1	5397.37	97.47	+50	5397.97
						1	nn D	41.6445	5406.30	0	5406.30	106.40	+50	5406.90
2	n D	41.0046	5410.35	-32	5410.03	2	D	41.5651	5410.14	0	5410.14	109.09	+50	5410.59
1	nn D	40.9277	5414.10	-32	5413.78	1-2	B	41.5310	5411.79	0	5411.79	11.89	+50	5412.39
4	B	40.8673	5417.05	-32	5416.73	1-2	n D	41.4980	5413.39	+1	5413.40	13.59	+50	5414.09
6	wn D	40.7959	5420.55	-32	5420.23	2	n B	41.4366	5416.38	+1	5416.39	16.56	+50	5417.06
1	n D	40.7109	5424.73	-32	5424.42	2	D	41.3703	5419.61	+1	5419.62	19.93	+50	5420.43
3	n D	40.5995	5430.23	-31	5429.92	3	n B	41.3123	5422.44	+1	5422.45	22.55	+50	5423.05
1	nn D	40.5200	5434.17	-31	5433.86	2	n D	41.2679	5424.62	+2	5424.64	24.53	+59	5425.03
Max	D	40.2479	5447.74	-30	5447.44	4	D	41.1642	5429.72	+2	5429.74	29.83	+50	5430.33
3	B	40.1815	5451.08	-30	5450.78	3	B	41.1254	5431.63	+2	5431.65	31.75	+50	5432.25
1	n D	40.0686	5456.77	-30	5456.47	2	n D	41.0808	5433.82	+2	5433.84	33.85	+50	5434.35
1	n D	39.9823	5461.14	-29	5460.85	9	D	40.8159	5446.99	+3	5447.02	47.23	+50	5447.73
1	n D	39.8744	5466.63	-29	5466.34	2	B	40.7560	5449.98	+3	5450.01	50.40	+51	5450.91
3	n B	39.7607	5472.43	-28	5472.15	2	n D	40.6298	5456.32	+3	5456.35	56.41	+51	5456.92
						2	n D	40.5554	5460.67	+4	5460.11	60.48	+51	5460.99
1	n D	39.5595	5482.77	-28	5482.49	3	B	40.3283	5471.59	+4	5471.63	66.24	+51	5476.75
1	B	39.3182	5495.29	-26	5495.03	1	n D	40.2899	5473.55	+4	5473.59	73.69	+51	5478.20
5	D	39.2723	5497.68	-26	5497.42	1	n D	40.2149	5477.39	+4	5477.43	77.53	+51	5482.94
						2	n D	40.1169	5482.42	+4	5482.46	82.48	+51	5487.99
						2	B	39.8698	5485.19	+5	5485.24	95.14	+51	5490.65
						5	D	39.8283	5497.35	+5	5497.40	97.41	+51	5499.32
						4	n D	39.7458	5501.65	+5	5501.70	101.80	+51	5502.31
						1	n D	39.6583	5506.23	+5	5506.28	106.38	+51	5506.89
1 2	n D	38.9961	5512.19	-24	5511.95	2	wn B	39.6205	5508.22	+5	5508.27	108.37	+51	5508.88
Con. 1	from	38.9720	5513.50	-24	5513.26	2 3	n D	39.5505	5511.90	+5	5511.95	11.95	+51	5512.46
Spec. 1	to	38.7880	5523.20	-23	5522.97	Con. 1	from	39.5240	5513.30	+5	5513.35	13.31	+51	5513.82
1	n D	38.7687	5524.26	-23	5524.03	1	nn D	39.3530	5522.36	+4	5522.40	22.69	+51	5523.2
1	nn D	38.7000	5527.90	-22	5527.68	1	nn D	39.3288	5523.63	+4	5523.67	23.85	+51	5524.36
1	n D	38.5912	5533.76	-21	5533.55							27.58	+51	5528.09
9	D	38.4818	5539.65	-20	5539.45	1	n D	39.1515	5533.10	+4	5533.14	33.35	+51	5533.86
						7	D	39.0395	5539.11	+4	5539.15	39.30	+51	5539.81
2 3	n B	38.4125	5543.40	-20	5543.20	1	from	39.0080	5544.00	+4	5544.04	44.14	+51	5544.7
1	n D	38.3335	5547.68	-19	5547.49	B 1	to	38.9110	5546.10	+4	5546.14	43.10	+51	5543.61
1	n D	38.1797	5556.06	-18	5555.88	1-2	D	38.8841	5547.51	+4	5547.55	46.24	+51	5546.8
1	n B	38.0298	5564.29	-16	5564.13	1	nn D	38.6247	5561.55	+3	5561.58	61.68	+52	5562.20
1	n D	37.9876	5566.61	-16	5566.45	1	n B	38.5843	5563.87	+3	5563.90	64.02	+52	5564.54
1	n B	37.9020	5571.34	-15	5571.19	1	nn D	38.5429	5566.15	+3	5566.18	66.32	+52	5566.84
						2	B	38.4555	5571.07	+2	5571.09	71.14	+52	5571.66
						1	nn D	38.4240	5572.71	+2	5572.73	72.83	+52	5573.4
9	D	37.6804	5583.65	-13	5583.52	1	n D	38.3669	5575.86	+2	5575.88	75.98	+52	5576.50
2	B	37.6268	5586.65	-12	5586.53	9	D	38.2360	5583.14	+1	5583.15	83.34	+52	5583.86
1	nn D	37.5900	5588.70	-12	5588.58	4	B	38.1785	5586.35	+1	5586.36	86.45	+52	5586.97
1	n B	37.5402	5591.51	-11	5591.40	1	n D	38.1459	5588.17	+1	5588.18	88.38	+52	5588.90
1	n D	37.5002	5593.76	-11	5593.65							91.30	+52	5591.82
2	n B	37.4529	5596.42	-10	5596.32	1	n D	38.0398	5594.13	0	5594.13	93.89	+52	5594.41
1-2	nn D	37.3884	5600.07	-9	5599.88	2-3	n B	37.9992	5596.41	0	5596.41	96.37	+52	5596.89
Con. 1	from	37.2338	5608.84	-7	5608.77	1	n D	37.9477	5599.31	0	5599.31	99.65	+52	5600.17
		37.2150	5609.90	-7	5609.83	2	n D	37.7891	5598.30	-1	5608.29	108.53	+52	5609.05
						1	n D	37.6748	5614.82	-2	5614.80	14.90	+52	5615.42
Spec. 1	to	37.0760	5617.84	-5	5617.79	1 2	n B	37.6452	5616.51	-2	5616.49	16.59	+52	5617.11
	D	37.0440	5619.68	-5	5619.63							17.69	+52	5618.2
	D	36.9600	5624.51	-3	5624.48	3	n D	37.5958	5619.35	-2	5619.33	19.48	+52	5620.00
Con. 1	from	36.9290	5626.30	-3	5626.27	1	D	37.5195	5623.73	-3	5623.70	24.09	+52	5624.61
Spec. 10	to	36.8510	5630.80	-2	5630.78	Con. 1	from	37.4820	5625.90	-3	5625.87	26.07	+52	5626.6
	D	36.8072	5633.35	-1	5633.34	Spec. 10	to	37.3930	5631.10	-3	5631.07	30.93	+52	5631.5
								36.3548	5633.24	-4	5633.20	33.27	+52	5633.79

## 132 SCHJELLERUP—Continued

PLATE G 281										MEAN WAVE-LENGTH				
Line	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
			t.m.						t.m.		t.m.	t.m.		t.m.
1-2	Head	36.7353	5637.54	-1	5636.35		Head	37.3100	5635.84	-4	5635.80	36.08	+52	5636.60
	n B	36.7356	5637.54	0	5637.54	3-4	n B	37.2867	5637.19	-4	5637.15	37.35	+52	5637.87
1	n D	36.7145	5638.97	0	5638.97							38.87	+52	5639.39
1-2	n B	36.6834	5640.54	+1	5640.55	3-4	n B	37.2398	5639.93	-4	5639.89	40.22	+52	5640.74
	n D	36.6307	5643.63	+2	5643.65	1-2	nn D	37.1849	5643.13	-5	5643.08	43.37	+52	5643.89
						1	n B	37.1431	5645.58	-5	5645.53	45.63	+52	5646.15
						1	n B	36.9852	5654.85	-6	5654.79	54.89	+53	5655.42
						1	n D	36.9428	5657.36	-6	5657.30	57.40	+53	5657.93
1	n D	36.1689	5670.90	+10	5671.00	1	nn D	36.7302	5669.97	-6	5669.91	70.46	+53	5670.99
1	n D	36.0785	5676.24	+12	5676.36	1	nn D	36.6357	5675.61	-7	5675.54	75.95	+53	5676.48
1	nn D	35.9256	5685.49	+15	5685.64	1	nn D	36.4636	5685.96	-8	5685.88	85.76	+53	5686.29
4	n B	35.8105	5692.45	+17	5692.62	4	B	36.3503	5692.82	-9	5692.73	92.68	+53	5693.21
						1	nn D	36.2948	5696.19	-10	5696.09	96.19	+53	5696.72
2	n B	35.6228	5703.87	+21	5704.08	4	B	36.1661	5704.04	-11	5703.93	104.00	+53	5704.53
1-2	n D	35.5629	5707.54	+22	5707.76	2	n D	36.1656	5707.75	-11	5707.64	107.70	+53	5708.23
						1	B	36.0658	5710.19	-11	5710.08	108.18	+53	5710.71
1	n D	35.4971	5711.56	+23	5711.79	2	n D	36.0375	5711.94	-12	5711.82	111.80	+53	5712.33
B	from	35.4690	5713.50	+20	5713.70							113.60	+53	5714.11
	to	35.3790	5718.90	+30	5719.20	5	nn B	35.9747	5715.80	-12	5715.68	115.78	+53	5716.31
	n D	35.3473	5720.82	+30	5721.12							119.10	+53	5719.61
2-3	B	35.3117	5723.02	+30	5723.32	4	nn B	35.8461	5723.76	-13	5723.62	123.47	+53	5724.00
3-4	n D	35.1870	5731.80	+30	5731.10	2	D	35.7394	5730.41	-14	5730.27	134.19	+53	5730.72
B	from	35.1570	5732.70	+40	5733.10	B	from	35.7150	5732.00	-14	5731.86	132.5	+53	5733.00
1	to	35.0290	5740.60	+40	5741.00		to	35.5730	5740.80	-15	5740.65	140.83	+53	5741.40
	n D	34.9955	5742.77	+40	5743.17	2	n D	35.4534	5748.25	-16	5748.06	148.90	+53	5749.43
1	nn D	34.9234	5749.30	+40	5749.70	2	n D	35.2506	5761.26	-18	5761.08	161.18	+54	5761.72
						1-2	B	35.1708	5766.37	-19	5766.18	166.28	+54	5766.82
2	n D	34.5817	5769.03	+40	5769.43		w D	35.1245	5769.34	-19	5769.15	169.25	+54	5769.79
	from	34.5550	5770.70	+40	5771.10	1-2	B	35.0553	5773.79	-20	5773.59	173.69	+54	5774.23
B						1-2	B	34.9712	5779.22	-21	5779.01	179.11	+54	5779.65
	to	34.4090	5780.10	+40	5780.50							180.40	+54	5780.90
	D	34.3990	5782.70	+40	5783.10	D	from	34.9520	5780.50	-21	5780.29	180.39	+54	5780.90
							to	34.8620	5786.30	-22	5786.08	186.18	+54	5786.51
						1	nn D	34.8260	5788.90	-22	5788.48	188.58	+54	5789.06
1	n D	34.1639	5796.06	+1.1	5797.	1	nn D	34.7620	5792.90	-23	5792.67	192.77	+54	5793.33
						1	n D	34.6851	5797.20	-24	5796.96	197.06	+54	5797.60
1	D	34.0431	5803.96	+1.1	5805.	1	n D	34.6066	5803.00	-25	5802.75	202.85	+54	5803.39
						2	n D	34.3239	5821.74	-27	5821.47	211.57	+54	5822.11
						1	n D	34.2652	5829.68	-29	5829.39	219.49	+54	5830.03
						Max	B	34.0230	5842.00	-30	5841.70	241.80	+54	5842.34
End		32.9740	5876.0	+1.1	5876.	End		33.3700	5886.90	-30	5886.60	.....	.....	.....

## 115 SCHJELLERUP

PLATE G 281						PLATE G 282						MEAN WAVE-LENGTH		
1899, December 25, G.M.T. 2100. Hour angle, W 110 Star poor; comparison fair						1900, January 31, G.M.T. 1003. Hour angle, W 117 Star fair; comparison fair								
Line	Character	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Character	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
			t.m.		t.m.				t.m.		t.m.	t.m.		t.m.
1	nn D	55.3280	4404.82	-11	4404.71	...	nn D	55.3280	4404.82	-11	4404.71	01.73	+19	4404.92
1	n D	55.3004	4407.81	-12	4407.69	1	n D	55.3004	4407.81	-12	4407.69	07.71	+19	4407.90
1	n D	55.0090	4416.87	-15	4416.72	1	n D	55.0090	4416.87	-15	4416.72	16.74	+19	4416.93
4-5	nn D	54.4137	4435.46	-20	4435.26	4-5	nn D	54.4137	4435.46	-20	4435.26	35.28	+19	4435.47

## 115 SCHJELLERUP - Continued

PLATE G 363						PLATE G 362						MEAN WAVE-LENGTH			
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	
		mm.	t. m.		t. m.			mm.	t. m.		t. m.	t. m.		t. m.	
...	...	...	...	...	...	3	n B	54.3122	4438.70	-20	4438.50	38.52	+19	4438.71	
...	...	...	...	...	...	2 3	wn D	53.9600	4450.04	-23	4449.81	49.83	+19	4450.02	
...	...	...	...	...	...	...	n D	53.5890	4462.18	-24	4461.94	61.96	-20	4462.2	
...	...	...	...	...	...	1	D	53.3279	4470.87	-24	4470.63	70.65	-20	4470.85	
...	...	...	...	...	...	2	n B	53.2443	4473.67	-24	4473.43	73.45	-20	4473.65	
1	n B	50.5985	4478.12	+28	4478.40	...	...	...	...	...	...	78.38	-20	4478.58	
...	...	...	...	...	...	2	n B	52.9343	4484.15	-24	4483.91	83.93	-20	4484.13	
...	...	...	...	...	...	2	n D	52.9075	4485.07	-24	4484.83	84.85	-20	4485.05	
1	n D	50.0670	4496.57	+25	4496.82	...	...	...	...	...	...	85.67	-20	4485.87	
1	nn D	49.9557	4500.49	+24	4500.73	1 2	n D	52.8835	4485.89	-24	4485.65	86.84	-20	4485.87	
...	...	...	...	...	...	1	n D	52.5580	4497.09	-23	4496.86	96.84	-20	4497.04	
1-2	n D	49.7954	4506.18	+24	4506.42	...	...	...	...	...	...	00.71	-20	4500.91	
...	...	...	...	...	...	1	n B	52.3616	4503.92	-23	4503.69	03.71	-20	4503.91	
...	...	...	...	...	...	2	n D	52.2772	4506.89	-23	4506.66	06.54	-20	4506.74	
...	...	...	...	...	...	3	n B	52.2392	4508.22	-23	4507.99	08.01	-20	4508.21	
...	...	...	...	...	...	1 2	nn D	52.1026	4513.05	-22	4512.83	12.85	-20	4513.05	
...	...	...	...	...	...	1 2	n D	51.9575	4518.20	-21	4517.99	18.01	-20	4518.21	
...	nn D	49.3424	4522.48	+22	4522.70	2 3	n D	51.8164	4523.25	-20	4523.05	22.88	-20	4523.08	
...	...	...	...	...	...	3	n B	51.7799	4524.57	-20	4524.37	24.39	-20	4524.59	
...	nn D	48.9980	4535.11	+21	4535.32	...	n D	51.6999	4527.45	-19	4527.26	27.28	-20	4527.48	
...	n B	48.9534	4536.76	+21	4536.97	...	n D	51.4760	4535.58	18	4535.40	35.36	-20	4535.56	
...	...	...	...	...	...	...	n B	51.4330	4537.16	-17	4536.99	36.98	-20	4537.08	
...	...	...	...	...	...	1	B	51.3933	4538.61	17	4538.44	38.46	-20	4538.66	
...	wn D	48.5380	4552.31	+20	4552.51	1	B	51.1457	4547.74	-15	4547.59	47.61	-20	4547.81	
...	...	...	...	...	...	4	n D	50.9777	4554.00	-13	4553.87	52.49	-20	4552.69	
...	nn D	48.3365	4559.97	+20	4560.17	...	...	...	...	...	...	53.89	-20	4554.09	
B	from	48.1690	4566.39	-20	4566.59	...	...	...	...	...	...	60.15	-20	4560.35	
0-1	to	48.1020	4568.97	-20	4569.17	...	...	...	...	...	...	66.57	-20	4566.8	
...	B	47.9985	4572.98	-20	4573.18	...	...	...	...	...	...	69.15	-20	4569.4	
D	from	47.9890	4573.35	-20	4573.55	...	...	...	...	...	...	73.16	-20	4573.36	
...	to	47.9000	4576.81	-20	4577.01	...	...	...	...	...	...	73.53	-20	4573.7	
...	...	...	...	...	...	...	nn D	50.0410	4589.87	+4	4589.91	76.99	-20	4577.2	
1	n D	47.5459	4590.75	+21	4590.96	...	...	...	...	...	...	89.93	-20	4590.13	
0-1	nn D	47.4864	4593.12	+21	4593.33	...	...	...	...	...	...	90.94	-20	4591.14	
...	n D	47.4005	4596.55	+21	4596.76	...	...	...	...	...	...	93.31	-20	4593.51	
...	...	...	...	...	...	...	nn D	49.8490	4597.44	+8	4597.52	97.14	-20	4597.34	
...	...	...	...	...	...	1	nn D	49.7752	4600.37	+9	4600.46	00.48	-20	4600.68	
...	...	...	...	...	...	...	from	49.6580	4605.04	+12	4605.16	05.18	-20	4605.4	
2 3	n D	47.1697	4605.84	+22	4606.06	D	to	49.5790	4608.20	+12	4608.32	06.04	-20	4606.24	
1-2	n D	47.0049	4612.53	+22	4612.75	...	...	...	...	...	...	08.34	-20	4608.5	
...	...	...	...	...	...	3	n B	49.3524	4617.36	+16	4617.52	12.71	-20	4612.91	
1	n D	46.8450	4619.08	+22	4619.30	2	n D	49.3124	4618.98	+16	4619.14	17.54	-20	4617.74	
...	...	...	...	...	...	2	n D	49.2172	4622.87	+17	4623.04	19.22	-20	4619.42	
...	...	...	...	...	...	1-2	n B	48.8429	4638.32	+24	4638.56	23.06	-20	4623.26	
...	nn D	45.7074	4667.27	+28	4667.55	1-2	nn D	48.8047	4639.91	+24	4640.15	28.38	-20	4638.78	
...	...	...	...	...	...	...	...	...	...	...	...	40.17	-20	4640.37	
...	...	...	...	...	...	1-2	n D	47.9970	4674.37	+33	4674.70	67.53	-20	4667.73	
1	n D	45.0400	4696.91	+34	4697.25	...	...	...	...	...	...	74.72	-20	4674.92	
...	...	...	...	...	...	0 1	D	46.9420	4721.68	+39	4722.07	97.21	-20	4697.41	
...	...	...	...	...	...	1	D	46.7818	4729.10	+39	4729.49	22.09	-20	4722.29	
...	nn D	44.2260	4734.51	+40	4734.91	...	...	...	...	...	...	29.51	-20	4729.71	
3	n B	44.1447	4738.36	+41	4738.77	4	B	46.5858	4738.27	+39	4738.66	34.89	-20	4735.09	
1	n D	44.1187	4739.60	+41	4740.01	...	...	...	...	...	...	38.72	-20	4738.92	
10	D	44.0418	4743.26	+42	4743.68	...	w D	46.4882	4742.87	+39	4743.26	39.99	-20	4740.19	
Head		44.0112	4744.72	+42	4745.14	...	...	46.4404	4744.93	+39	4745.32	43.47	-20	4743.67	
B	to	43.9450	4747.88	+42	4748.30	Head	4-5	B	46.4204	4746.09	+39	4746.48	45.23	-20	4745.43
...	nn D	43.9240	4748.89	+42	4749.31	...	...	...	...	...	...	46.50	-20	4746.70	
...	nn D	43.8658	4751.69	+42	4752.01	...	...	...	...	...	...	48.28	-20	4748.5	
...	n B	43.8075	4754.50	+42	4754.92	...	...	...	...	...	...	49.29	-20	4749.49	
...	...	...	...	...	...	...	nn B	46.2173	4755.78	+39	4756.17	51.99	-21	4752.20	
...	nn D	43.7227	4758.61	+43	4759.04	...	wn D	46.1725	4757.94	+39	4758.33	54.90	-21	4755.11	
...	nn D	43.5640	4766.35	+44	4766.79	...	...	...	...	...	...	56.19	-21	4756.40	
...	...	...	...	...	...	...	...	...	...	...	...	58.69	-21	4758.90	
...	...	...	...	...	...	...	...	...	...	...	...	66.77	-21	4766.98	

## 115 SCHJELLERUP—Continued

PLATE G 32						PLATE G 32						MEAN WAVE-LENGTH		
Inten-	Char-	M. Scale Reading	W. Length by Formula	Cor. from Curve	Wave- Length	Inten-	Char-	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
B	nn D	43.4590	4771.50	+11	4771.94	2	n D	45.8917	4771.56	+37	4771.93	71.94	+21	4772.15
	from	43.4380	4772.54	+44	4772.98		nn B	45.8163	4775.25	+37	4775.62	72.96	+21	4773.2
	to	43.4440	4777.73	+44	4778.17							75.64	+21	4775.85
	nn D	43.2117	4783.77	+11	4784.21		nn D	45.6433	4783.61	+36	4784.00	78.15	+21	4778.4
B	nn D	43.1119	4788.77	+44	4789.21	1	n D	45.5444	4788.71	+35	4789.06	84.11	+21	4784.32
	from	43.0870	4790.01	+44	4790.45		from	45.5250	4789.66	+35	4790.01	89.14	+21	4789.35
	to	42.9740	4795.71	+11	4796.15	B	Max	45.4380	4794.03	+34	4794.37	90.23	+21	4790.4
	nn D	42.7862	4805.27	+44	4805.71		to	45.4090	4795.48	+34	4795.82	94.39	+21	4794.60
2	n B	42.7027	4809.56	+15	4810.01		wn D	45.2170	4805.19	+32	4805.51	95.99	+21	4796.2
												05.61	+21	4805.82
2	n B	42.6401	4813.28	+45	4813.73	1	n D	45.0995	4811.18	+31	4811.49	09.99	+21	4810.20
2 3	n D	42.5982	4814.94	+45	4815.39	1-2	n D	45.0229	4815.11	+30	4815.41	11.51	+21	4811.72
B	from	42.5740	4816.19	+45	4816.64		from	45.0000	4816.27	+29	4816.56	13.71	+21	4813.92
	to	42.4740	4821.38	+44	4821.82	B	to	44.8960	4821.64	+28	4821.92	15.40	+21	4815.61
							n D	44.8744	4822.76	+28	4823.04	16.60	+21	4816.8
						1	n D	44.8280	4825.18	+28	4825.46	21.87	+21	4822.1
1	nn D	42.3615	4827.26	+11	4827.70	2	n D	44.7862	4827.35	+27	4827.62	23.06	+21	4823.27
1-2	nn D	42.2722	4831.96	+44	4832.40	2-3	n B	44.7425	4829.63	+26	4829.89	25.48	+21	4825.69
	nn D	41.9100	4851.24	+44	4851.68		n B	44.6944	4831.88	+25	4832.13	27.67	+21	4827.88
	from	41.8320	4854.90	+44	4855.34		from	44.2640	4854.96	+19	4855.15	29.91	+21	4830.12
	to	41.6410	4865.81	+43	4866.24	B	Max	44.1507	4861.07	+16	4861.23	32.27	+21	4832.48
0 1	n D	41.6222	4866.85	+43	4867.28	1 2	n D	44.0840	4864.73	+15	4864.88	51.66	+21	4851.87
B	nn D	41.3720	4880.63	+42	4881.15	1 2	n D	43.7907	4880.75	+11	4880.86	55.25	+21	4855.5
	from	41.1520	4892.92	+41	4893.33	1 2	n D	43.6319	4889.56	+9	4889.65	65.6	+21	4865.8
	to	41.0190	4900.44	+41	4900.85	B	from	43.5760	4892.67	+8	4892.75	67.22	+21	4867.43
	D	41.0042	4901.28	+40	4901.68		to	43.4160	4901.66	+7	4901.73	80.88	+21	4881.09
1-2	n B	40.9810	4902.59	+40	4902.99							89.67	+21	4889.88
1	nn D	40.8482	4910.17	+40	4910.57	2	n D	43.2725	4909.82	+6	4909.88	93.03	+21	4893.2
1	n D	40.6961	4920.66	+38	4921.04							01.27	+21	4901.5
1	n D	40.6026	4924.34	+38	4924.72		wn D	42.0619	4981.44	-3	4981.41	01.66	+21	4901.87
												02.97	+21	4903.18
												10.28	+21	4910.49
												21.02	+21	4921.23
												24.70	+21	4924.91
												81.43	+22	4981.65

## 115 SCHJELLERUP

PLATE G 33						PLATE G 34						MEAN WAVE-LENGTH		
1900, January 7, G.M.T. 2:05. Hour angle, W 138. Star good; comparison fair						1900, January 7, G.M.T. 2:05. Hour angle, W 263. Star good; comparison good								
Inten-	Char-	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten-	Char-	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Uncor- rected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
2	n D	45.7520	5166.77	+22	5166.99							67.01	+23	5167.24
B	from	45.7270	5167.78	+22	5168.00							68.02	+23	5168.3
	to	45.6140	5172.45	-21	5172.56		nn B	46.5144	5170.54	+20	5170.74	70.73	+23	5170.96
	n D	45.5014	5173.29	+21	5173.50							72.58	+23	5172.8
	from	45.5610	5174.50	-21	5174.71		nn D	46.4433	5173.42	+19	5173.61	73.56	+23	5173.79
B	to	45.3900	5182.69	+19	5182.88							74.73	+23	5175.0
2 3	n D	45.3385	5183.55	+19	5183.74		nn D	46.2114	5182.81	+17	5183.01	82.00	+23	5183.2
B	from	45.3130	5184.61	+19	5184.80							83.38	+23	5183.61
	to	45.2240	5188.27	+18	5188.45							84.82	+23	5185.1
	n D	45.2038	5189.00	+18	5189.18							88.47	+23	5188.8
												89.20	+23	5189.43

## 115 SCHJELLERUP—Continued

PLATE G 365						PLATE G 374						MEAN WAVE-LENGTH			
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.	
2	n B	45.1734	5190.37	+18	5190.55							90.57	+23	5190.80	
	wn D	45.1025	5193.30	+18	5193.48	nn D	45.9565	5193.30	+14	5193.44		93.46	+23	5193.69	
	from	45.0520	5195.36	+17	5195.53							95.55	+23	5195.8	
B	to	44.8320	5204.51	+16	5204.67							04.69	+23	5204.9	
						nn D	45.5330	5210.91	+10	5211.01		11.00	+23	5211.23	
D	to	44.6390	5212.60	+15	5212.75							12.77	+23	5213.0	
4	n B	44.6065	5213.99	+15	5214.14	3	n B	45.4592	5214.00	+10	5214.10		14.12	+23	5214.35
	nn D	44.5520	5216.26	+14	5216.40	nn D	45.4030	5216.37	+10	5216.47		16.44	+23	5216.67	
	from	44.5200	5217.62	+14	5217.76							17.78	+23	5218.0	
B	to	44.3550	5224.61	+14	5224.75							21.77	+23	5225.0	
8	nn D	44.3124	5226.44	+14	5226.58	2	n D	45.1650	5226.44	+8	5226.52		26.55	+23	5226.78
	from	44.2700	5228.23	+14	5228.37		nn B	45.0709	5230.44	+7	5230.51		28.39	+23	5228.6
B	to	44.1760	5232.25	+14	5232.39							30.50	+23	5230.73	
3	nn D	44.1515	5233.33	+14	5233.47	2-3	n D	44.9883	5233.97	+7	5234.04		32.41	+23	5232.6
6	wn B	44.0825	5236.29	+14	5236.43		n B	44.9305	5236.45	+6	5236.51		33.76	+23	5233.99
						nn D	44.8554	5239.68	+6	5239.74		36.47	+23	5236.70	
												39.73	+23	5239.96	
3	wn B	43.8963	5244.32	+13	5244.45							44.47	+23	5244.70	
3	nn D	43.8789	5246.81	+13	5246.94							46.96	+23	5247.19	
	n D	43.7377	5251.22	+13	5251.35	nn D	44.5752	5251.80	+5	5251.85		51.60	+23	5251.83	
	n D	43.7054	5270.22	+13	5270.35	nn D	44.1457	5270.64	+4	5270.68		70.52	+23	5270.75	
	nn B	43.0890	5279.87	+14	5280.01		nn B	43.9420	5279.69	+4	5279.73		79.87	+23	5280.10
2 3	D	42.6942	5297.67	+16	5297.83	2	n D	43.5260	5298.39	+5	5298.44		98.14	+23	5298.37
	nn D	42.5400	5304.71	+17	5304.88		nn B	43.3840	5304.85	+6	5304.91		04.90	+23	5305.13
	n B	42.3692	5312.55	+18	5312.73	3	n B	43.2060	5313.00	+6	5313.06		12.90	+23	5313.13
2 3	nn D	42.3214	5314.75	+19	5314.94	3	n D	43.1597	5315.13	+6	5315.19		15.07	+23	5315.30
9	n B	42.2672	5317.26	+19	5317.45	7	B	43.1052	5317.64	+7	5317.71		17.58	+23	5317.81
1	nn D	42.2055	5320.10	+20	5320.30	3	nn D	43.0415	5320.58	+7	5320.65		20.48	+23	5320.71
	n B	41.8519	5336.64	+24	5336.88	4	n D	42.6999	5336.49	+10	5336.59		36.74	+23	5336.97
	n B	41.8054	5338.82	+25	5339.07	6	n B	42.6474	5338.95	+10	5339.05		39.06	+23	5339.29
5	n D	41.7544	5341.23	+27	5341.50	3	n D	42.5935	5341.49	+11	5341.60		41.55	+23	5341.78
	nn B	41.6914	5344.21	+28	5344.49	nn B	42.5327	5344.35	+11	5344.46		44.48	+23	5344.71	
4	n B	41.5324	5351.77	+30	5352.07	1-2	n B	42.3685	5352.13	+12	5352.25		52.16	+23	5352.39
						B	from	42.3060	5355.11	+13	5355.24		55.22	+23	5355.5
						1 2	n D	42.1100	5364.49	+15	5364.64		64.02	+23	5364.9
								42.0863	5365.62	+15	5365.77		65.76	+23	5365.99
1	n D	41.2200	5366.77	+36	5367.13							67.15	+23	5367.38	
3	n B	41.1918	5368.14	+36	5368.50	2	n B	42.0308	5368.29	+16	5368.45		68.48	+23	5368.71
						from	42.0000	5369.78	+16	5369.94		69.93	+23	5370.2	
7	wn D	41.1324	5371.01	+38	5371.39	D	to	41.9240	5373.37	+17	5373.54		71.41	+23	5371.64
						5	B	41.8970	5374.76	+17	5374.93		73.49	+23	5373.7
8	n B	41.0650	5374.24	+38	5374.62	3	n D	41.8535	5376.87	+17	5377.04		74.78	+23	5375.01
3	n D	41.0155	5376.70	+38	5377.08							77.06	+23	5377.29	
	from	40.9910	5377.86	+39	5378.25							78.27	+23	5378.5	
B	to	40.9170	5381.48	+40	5381.88	9	wn B	41.7834	5380.28	+18	5380.46		80.45	+23	5380.68
	from	40.8060	5386.93	+41	5387.34							81.90	+23	5382.1	
B	to	40.6730	5393.49	+43	5393.92	4-5	wn B	41.5280	5392.78	+21	5392.99		87.36	+23	5387.6
	wn D	40.6217	5396.05	+44	5396.49							92.98	+23	5393.21	
	from	40.5490	5399.64	+45	5400.09	3	nn D	41.4502	5396.32	+22	5396.54		95.94	+23	5394.2
B	to	40.3090	5407.12	+46	5407.58	Con. Spec.	from	41.4290	5397.67	+23	5397.90		99.0	+23	5396.75
	nn D	40.3628	5408.95	+46	5409.41	to	41.2280	5407.64	+25	5407.89		07.74	+23	5408.0	
3	n B	40.3099	5411.61	+47	5412.08	3	n D	41.1914	5409.47	+25	5409.72		09.57	+23	5409.80
1 2	n D	40.2805	5413.08	+47	5413.55	1	n B	41.1447	5411.80	+26	5412.06		12.07	+23	5412.30
7 8	wn B	40.2187	5416.20	+48	5416.68	5	n B	41.0490	5416.59	+26	5416.85		13.57	+23	5413.80
						3	nn D	40.9813	5420.00	+27	5420.27		16.77	+23	5417.00
3	n B	40.0904	5422.68	+49	5423.17	3	n B	40.9282	5422.98	+28	5423.26		20.26	+23	5420.49
						nn D	40.8849	5424.86	+28	5425.14		23.22	+23	5423.45	
2 3	n B	40.0182	5426.35	+50	5426.85	3	n B	40.8452	5426.87	+28	5427.15		25.13	+23	5425.36
	nn D	39.9620	5429.19	+51	5429.70	3	D	40.7857	5429.89	+29	5430.18		26.95	+23	5427.18
	from	39.7000	5439.53	+52	5440.05	1	n B	40.7515	5431.63	+30	5431.93		29.94	+23	5430.17
B	to	39.6680	5444.27	+53	5444.80	B	from	40.5920	5439.77	+30	5440.07		31.92	+23	5432.15
6	n D	39.6192	5446.82	+53	5447.35	7	to	40.5040	5444.28	+31	5444.59		40.06	+23	5440.3
							n D	40.4520	5446.96	+31	5447.27		44.70	+23	5444.9
												47.31	+23	5447.54	

## 115 SCHJELLERUP—Continued

PLATE G 332					PLATE G 374					MEAN WAVE-LENGTH				
Line	Char-acter	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Inten-sity	Char-acter	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Uncor-rected for Velocity	Cor. for V	Corrected for Velocity
		t.m.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.
1.5	wn B	39.5588	5449.95	+53	5450.48	4	B	40.3835	5450.49	+32	5450.81	50.65	+24	5450.89
						2	nn D	40.2790	5453.90	+33	5456.23	56.22	+24	5456.46
1	n B	39.4024	5458.08	+54	5458.62	1						58.64	+24	5458.88
	nn D	39.3679	5459.89	+54	5460.43	1	n D	40.1933	5460.35	+33	5469.68	60.56	+24	5460.80
	nn D	39.2209	5467.82	+54	5468.36	5	B	39.9759	5471.73	+35	5472.08	68.38	+24	5468.02
1	nn D	39.1130	5473.27	+55	5473.82	1.2	n D	39.9322	5474.03	+35	5474.38	72.07	+24	5472.31
	nn D	39.0324	5477.56	+55	5478.11							74.10	+24	5474.34
	nn B	38.9810	5480.30	+55	5480.85		nn B	39.8169	5480.12	+36	5480.48	80.67	+24	5478.37
	nn D	38.9345	5482.78	+56	5483.34							83.36	+24	5480.81
							nn D	39.1944	5497.31	+38	5497.69	97.68	+24	5497.92
							nn D	39.4079	5501.96	+38	5502.34	102.33	+24	5502.57
	from	38.5200	5404.73	+56	5505.29	B	to	39.3740	5503.79	+38	5504.17	104.73	+24	5505.0
	nn D	38.4400	5509.41	+55	5512.19	2	nn D	39.2600	5506.96	+38	5510.34	10.15	+24	5510.4
	from	38.3620	5513.66	+54	5514.20							11.96	+24	5512.20
	to	38.2000	5522.56	+54	5523.10							14.22	+24	5514.5
						2	n D	38.9910	5524.63	+39	5525.02	23.12	+24	5523.4
							nn D	38.8300	5533.50	+39	5533.89	25.01	+24	5525.25
1	n D	37.9073	5538.81	+53	5539.34	8	n D	38.7333	5538.86	+39	5539.25	33.72	+24	5533.96
	n D	37.8695	5540.92	+53	5541.45		from	38.6890	5541.32	+39	5541.71	39.30	+24	5539.54
	from	37.7840	5545.68	+53	5546.21	B	to	38.5970	5546.45	+39	5546.84	41.58	+24	5541.8
	to	37.7694	5547.26	+52	5547.78	2.3	n D	38.5649	5548.23	+39	5548.62	46.63	+24	5546.8
2	n B	37.6408	5553.77	+52	5554.29	1.2	D	38.4944	5552.19	+38	5552.57	48.21	+24	5548.45
	n D	37.6067	5555.53	+51	5556.04		n B	38.4655	5555.81	+38	5556.19	52.56	+24	5552.80
						1	n D	38.4297	5555.82	+38	5556.20	54.24	+24	5554.48
						1	n D	38.4238	5561.79	+38	5562.17	56.12	+24	5556.36
1.2	n B	37.4633	5563.84	+50	5564.34		nn B	38.2752	5564.54	+38	5564.92	62.16	+24	5562.40
							n D	38.2353	5566.81	+38	5567.19	64.63	+24	5564.87
	from	37.4080	5566.97	+50	5567.47							67.18	+24	5567.32
	to	37.3140	5572.35	+50	5572.85	Max	B	38.1680	5570.63	+38	5571.01	67.49	+24	5567.7
						1	n D	38.0620	5576.68	+38	5577.06	71.00	+24	5571.24
9	D	37.1290	5583.03	+49	5583.52	9	D	37.9469	5583.28	+37	5583.65	72.87	+24	5573.1
						limits		37.9810	5581.33	+37	5581.70	77.05	+24	5577.29
						limits		37.9120	5585.30	+37	5585.67	83.59	+24	5583.83
												81.69	+24	5581.9
												85.66	+24	5585.9
												85.97	+24	5586.21
Head	B	37.0800	5585.49	+48	5585.97		B	37.8789	5587.20	+37	5587.57	87.42	+24	5587.66
4	B	36.9802	5591.66	+47	5592.13	6	B	37.8008	5591.71	+37	5592.08	92.11	+24	5587.96
	to	36.9600	5592.86	+47	5593.33	8	B	37.8008	5591.71	+37	5592.08	93.35	+24	5593.6
	nn D	36.9648	5594.31	+46	5594.77		n D	37.7512	5594.59	+36	5594.95	94.86	+24	5595.10
	B	36.8912	5596.85	+46	5597.31	4	n B	37.7065	5597.18	+36	5597.54	97.43	+24	5597.67
	nn D	36.8469	5599.45	+46	5600.91	1	n D	37.6714	5599.23	+36	5600.59	99.79	+24	5600.03
							wn D	37.4997	5609.26	+34	5609.60	101.59	+24	5603.83
	nn D	36.5070	5610.46	+42	5610.91							109.59	+24	5620.17
	nn D	36.4155	5624.97	+41	5625.38		nn D	37.2122	5624.46	+33	5624.79	119.93	+24	5620.17
	from	36.3889	5626.53	+41	5626.94		from	37.1990	5627.03	+32	5627.35	125.40	+24	5625.64
	to	36.3410	5631.62	+40	5632.02	Con. Spec.	D	37.1180	5631.86	+32	5632.18	127.15	+24	5627.4
	D	36.2670	5633.88	+40	5634.28	10	D	37.0807	5634.09	+31	5634.40	132.10	+24	5632.3
		36.2194	5636.74	+40	5637.14		to	37.0310	5637.06	+30	5637.36	134.34	+24	5634.58
	to	36.1200	5642.73	+39	5643.12	B	to	36.9550	5643.41	+29	5643.73	137.25	+24	5637.49
							nn D	36.9044	5644.68	+29	5644.98	143.43	+24	5643.7
							from	36.8850	5645.85	+29	5646.14	144.96	+24	5645.20
	n B	36.6520	5645.57	+38	5645.95	B						146.13	+24	5646.4
	n B	36.5940	5654.29	+37	5654.66	2	n B	36.7283	5655.34	+27	5655.61	145.97	+24	5646.21
							to	36.7140	5656.22	+27	5656.49	155.1	+25	5655.3
	nn D	35.8754	5657.66	+37	5658.03		nn D	36.6963	5657.20	+27	5657.56	156.48	+25	5656.7
						Con. Spec.	from	36.6730	5658.71	+27	5658.98	157.80	+25	5658.05
							to	36.4910	5669.86	+25	5670.11	158.97	+25	5659.2
1.2	n D	35.6579	5671.07	+34	5671.41							170.10	+25	5670.4
2	n B	35.6220	5673.29	+34	5673.63	2	n B	36.1179	5674.25	+23	5674.58	71.43	+25	5671.68
						1	n D	36.3878	5676.20	+23	5676.43	74.06	+25	5674.31
	n B	35.5267	5679.59	+33	5679.92	2	n B	36.2384	5679.27	+22	5679.49	76.42	+25	5676.67
1.2	n B	35.4620	5683.20	+31	5683.51	2	n B	36.2500	5684.19	+21	5684.40	79.71	+25	5679.96
						1	n D	36.2249	5686.31	+21	5686.52	83.96	+25	5684.21
												86.51	+25	5686.76

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PLATE G 365						PLATE G 374						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
		mm.	t.m.		t.m.			mm.	t.m.		t.m.			t.m.
8	n B	35.2982	5693.54	+30	5693.84	7	n B	36.1055	5693.77	+20	5693.97	93.91	+25	5694.16
1	n D	35.2494	5696.61	+30	5696.91							96.93	+25	5697.18
2	n B	35.2134	5698.89	+29	5699.18	1	n B	36.0236	5698.90	+19	5699.09	99.14	+25	5699.39
4	n B	35.1234	5704.59	+28	5704.87	6	n B	35.9313	5704.72	+18	5704.90	04.89	+25	5705.14
						1	n D	35.8845	5707.67	+18	5707.85	07.84	+25	5708.09
2	n B	35.0267	5710.76	+27	5711.03							11.05	+25	5711.30
7	n B	34.9352	5716.61	+26	5716.87	8	n B	35.7407	5716.80	+16	5716.96	16.92	+25	5717.17
5	n B	34.8120	5724.54	+25	5724.79	8	n B	35.6236	5724.28	+14	5724.42	24.61	+25	5724.86
1-2	n D	34.7040	5731.52	+24	5731.76	2	n D	35.5107	5731.53	+14	5731.67	31.72	+25	5731.97
B	from	34.6770	5733.24	+24	5733.48	B	from	35.4920	5732.74	+13	5732.87	33.18	+25	5733.5
	to	34.5390	5742.23	+23	5742.46			35.3500	5741.93	+12	5742.05	42.26	+25	5742.6
						1	n D	35.3277	5743.37	+12	5743.49	43.48	+25	5743.73
						1	n D	35.2492	5748.48	+11	5748.59	48.58	+25	5748.83
B	from	34.3820	5752.53	+21	5752.74							52.76	+25	5753.0
	Max	34.3133	5757.10	+21	5757.31	Max	B	35.1160	5757.19	+10	5757.29	57.30	+25	5757.55
	to	34.2550	5760.92	+20	5761.12							61.14	+25	5761.4
3	n B	34.1602	5767.26	+19	5767.45	1	n D	35.0335	5762.62	+9	5762.71	62.70	+25	5762.95
	wn D	34.1017	5771.16	+19	5771.35		nn B	34.9640	5767.21	+9	5767.30	67.38	+25	5767.63
1-2	n B	34.0310	5775.89	+18	5776.07		wn D	34.9088	5770.85	+8	5770.93	71.14	+25	5771.39
2	n B	33.9660	5780.25	+18	5780.43	1	n B	34.8289	5776.17	+8	5776.25	76.16	+25	5776.41
	nn D	33.8890	5785.40	+18	5785.58	1 2	n B	34.7605	5780.72	+8	5780.80	80.62	+25	5780.87
	nn D	33.4122	5818.00	+16	5818.16		wn D	34.7040	5784.50	+7	5784.57	84.58	+25	5784.83
												18.18	+25	5818.43
	nn D	33.3192	5824.45	+16	5824.61		nn D	34.1332	5823.26	+6	5823.32	23.31	+25	5823.56
	nn D	33.2180	5831.46	+16	5831.62							24.63	+25	5824.88
												31.64	+25	5831.89
							nn D	33.7510	5849.83	+6	5849.89	49.88	+25	5850.13
							nn D	33.7283	5851.42	+6	5851.48	51.47	+25	5851.72
1 2	n D	32.8919	5854.44	+16	5854.60							54.62	+25	5854.87
	nn D	32.3880	5890.63	+16	5890.79							90.81	+25	5891.06
	nn D	32.3010	5897.01	+16	5897.17							97.19	+25	5897.44

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PLATE G 336						PLATE G 334					
1886, March 31, G.M.T. 1907. Hour angle, W 265 Spect. good; comparison good.						1880, April 4, G.M.T. 1753. Hour angle, W 267 Star excellent; comparison good.					
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length
Spec. begins		m.	m.		m.	Spec. begins		mm.	m.		m.
2 3	B	58.9690	4396.20	-10	4396.10	2	n B	61.7570	4397.10	-17	4396.93
3	n D	58.6310	4402.40	-12	4402.28			61.4442	4402.89	-18	4402.71
	from	58.4912	4405.05	-13	4404.92						
D	to	58.5770	4403.40	-12	4403.28	D	from	61.4100	4403.60	-18	4403.42
1	n D	58.2540	4408.50	-15	4409.35		to	61.0700	4410.10	-20	4409.90
1	n D	58.1867	4410.75	-16	4410.59						
1	n D	58.0933	4412.51	-17	4412.34	1	n D	60.9170	4412.93	-20	4412.73
4	n D	57.9313	4415.57	-18	4415.39	3	nn D	60.7711	4415.73	-21	4415.52
2	B	57.6350	4421.02	-20	4420.82						
2	B	57.4832	4424.10	-21	4423.89						
2	n D	57.3827	4426.03	-22	4425.81						
2	n D	57.2937	4427.75	-23	4427.52	2	n D	60.1277	4428.24	-25	4427.99
1-2	nn D	57.1416	4430.69	-24	4430.45	3 4	n D	60.0007	4430.72	-25	4430.47
6	wn D	56.8332	4436.28	-26	4436.02		wn D	59.7280	4436.20	-27	4435.93
1	n D	56.7420	4438.46	-28	4438.18						
1	nn D	56.4200	4444.80	-30	4444.50	1	n D	59.2771	4445.09	-29	4444.80
2 3	n D	56.2754	4447.64	-31	4447.33	1	n D	59.1274	4448.11	-29	4447.82
	wn D	56.1260	4450.60	-32	4450.28						
						1	n D	58.7524	4455.71	-31	4455.40
						1	n D	58.6200	4458.41	-31	4458.10
1	B	55.7027	4459.09	-35	4458.74						
	wn D	55.6427	4460.30	-36	4459.94						
4 5	n D	55.5430	4462.30	-36	4461.94		wn D	58.4201	4462.51	-32	4462.19
5	B	55.4503	4464.19	-37	4463.82	8	B	58.3192	4464.58	-32	4464.26
Con.	from	55.4130	4464.95	-37	4464.58						
						1	n D	58.1140	4468.83	-33	4468.50
						1	n D	57.9535	4472.16	-33	4471.83
Spec.	to	55.0190	4473.00	-38	4472.62						
	wn B	54.9770	4473.90	-38	4473.52						
	wn B	54.7200	4479.20	-40	4478.80						
2	n D	54.6613	4480.38	-40	4479.98						
2	n D	54.5512	4482.67	-41	4482.26	1	n D	57.4410	4482.95	-35	4482.60
Unre- j	from	54.5220	4483.28	-41	4482.87						
11 4						1	n D	57.3413	4485.03	-35	4484.68
						1	nn D	57.2196	4487.62	-35	4487.27
1	B	54.2850	4488.20	-42	4487.78						
		54.2508	4488.76	-42	4488.34						
7 4	D	54.1951	4490.12	-42	4489.70	2	D	57.1107	4489.94	-36	4489.58
Unre- j	from	54.1600	4490.86	-42	4490.44						
11 4	to	53.5890	4502.98	-44	4502.54	1	n D	56.5255	4502.54	-37	4502.17
						2 3	nn B	56.4500	4504.18	-37	4503.81
1	n D	53.4988	4505.13	-44	4504.69		n D	56.3958	4505.36	-37	4504.99
						2 3	nn B	56.3454	4506.46	-37	4506.09
2 3	nn D	53.3745	4507.58	-44	4507.14	1	nn D	56.2874	4507.73	-37	4507.36
1	nn D	52.9640	4516.48	-44	4516.04	1	nn D	56.0677	4513.21	-38	4512.83
1	B	52.8900	4517.65	-44	4517.22						
1 2	n D	52.8577	4518.80	-44	4518.36						
1	nn D	52.7749	4520.62	-44	4520.18						
6	n D	52.6402	4523.58	-44	4523.14	4	n D	55.5952	4523.69	-38	4523.31
1	B	52.5801	4524.80	-44	4524.45	6	B	55.4965	4525.16	-38	4524.78
1 2	nn D	5205.12	4536.65	-43	4536.23						

## 152 SCHJELLERUP

[illegible]

## 152 SCHJELLERUP—Continued

PLATE G 381						PLATE G 381					
Line	Class	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length
		mμ	Å.		Å.			mμ	Å.		Å.
4	n B	51.5974	4537.86	-12	4537.44		from	54.9510	4537.60	-38	4537.22
4	n B	51.6255	4539.48	-12	4539.06						
1	p D	51.8711	4549.70	-12	4549.28	1	n D	54.8170	4549.60	-38	4549.22
	wn D	51.6280	4543.94	-11	4543.53			54.7986	4541.02	-38	4540.64
5	n B	51.5481	4548.02	-41	4547.61	3	w D	54.5651	4546.37	-38	4545.99
5	n D	51.4797	4549.57	-41	4549.16	6	n B	54.4856	4548.20	-38	4547.82
							w D	54.4166	4549.80	-38	4549.42
							wn D	54.2770	4553.04	-37	4552.67
2	n D	50.9920	4560.77	-38	4560.39		D	53.9320	4561.08	-37	4560.71
1	n D	50.8720	4563.55	-38	4563.17	3	n D	53.8097	4563.96	-37	4563.59
2	n B	50.8120	4564.94	-38	4564.56						
1	n D	50.7657	4566.02	-37	4565.65	2	n D	53.7012	4566.52	-36	4566.16
2	n B	50.6820	4567.98	-37	4567.61						
							from	53.4990	4571.32	-36	4570.96
							to	53.1870	4578.77	-35	4578.42
2	n B	50.1698	4579.32	-34	4578.98						
1	nn D	50.1380	4580.79	-34	4580.45	2	n D	53.1010	4580.81	-35	4580.49
1-2	nn B	50.0925	4581.87	-34	4581.53	1	n D	52.9990	4583.30	-34	4582.96
1	nn D	49.8175	4588.43	-33	4588.10		from	52.7520	4589.28	-33	4588.95
							B				
2	n D	49.5700	4594.25	-31	4593.94	1	to	52.5790	4593.50	-33	4593.17
							n D	52.5471	4594.28	-33	4593.95
						Max	B	52.4862	4595.77	-33	4595.44
2	nn D	49.4420	4597.50	-31	4597.19						
Max	B	49.3580	4599.54	-30	4599.24	1	n D	52.2643	4601.23	-32	4600.91
Max	B	48.8170	4612.81	-28	4612.53						
1-2	D	48.7110	4613.94	-27	4613.67	1	n D	51.7387	4614.32	-29	4614.03
2	n B	48.7111	4614.43	-27	4615.16						
2	n D	48.6900	4616.39	-26	4616.41	1	n D	51.6203	4616.82	-29	4616.53
8	B	48.5962	4618.29	-26	4618.05	7	B	51.5719	4618.52	-28	4618.24
1	D	48.4200	4619.74	-26	4619.48	2	D	51.5169	4619.90	-28	4619.62
1-2	n D	48.4222	4622.63	-25	4622.38	1	n D	51.4000	4622.88	-28	4622.60
						1	n D	51.2770	4626.00	-27	4625.73
1	n D	47.8927	4638.50	-21	4638.09						

## 152 SCHJELLERUP—Continued

PLATE A 313						PLATE A 319						MEAN WAVE-LENGTH			
Intensity	Character	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Intensity	Character	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	
		mm.	t.m.		t.m.			mm.	t.m.		t.m.	t.m.		t.m.	
1	n B	46.6190	4537.87	+ 1	4537.88	2 3	n B	44.6949	4538.11	- 32	4537.79	37.70	- 2	4537.2	
2	n D	46.6693	4538.60	+ 2	4538.62	5	D	44.7372	4538.72	- 32	4538.40	38.51	- 2	4538.48	
1	n B	46.7195	4539.32	+ 2	4539.34	8	B	44.7878	4539.45	- 31	4539.14	39.18	- 2	4539.16	
...	...	...	...	...	...	...	nn D	44.8790	4540.77	- 31	4540.46	40.22	- 2	4540.2	
...	...	...	...	...	...	2-3	n D	45.0277	4542.92	- 30	4542.62	40.46	- 2	4540.44	
...	...	...	...	...	...	1	n B	45.1307	4544.41	- 29	4544.12	43.08	- 2	4543.06	
...	...	...	...	...	...	1	D	45.1970	4545.38	- 29	4545.09	43.53	- 2	4543.51	
2	n B	47.3029	4547.82	+ 2	4547.84	6	B	45.3773	4548.00	- 28	4547.72	44.12	- 2	4544.10	
...	...	...	...	...	...	...	...	...	...	...	...	45.54	- 2	4545.5	
1	n B	47.8705	4556.17	+ 3	4556.20	1	n B	45.9431	4556.30	- 25	4556.05	47.75	- 2	4547.73	
...	...	...	...	...	...	1	n B	46.1360	4559.10	- 23	4558.87	49.29	- 2	4549.27	
...	...	...	...	...	...	nn D	46.1780	4559.80	- 22	4559.58	52.67	- 2	4552.65		
...	...	...	...	...	...	1	n B	46.3627	4562.51	- 22	4562.29	56.05	- 2	4556.03	
2	n B	48.4499	4564.80	+ 5	4564.85	1	D	46.4690	4564.20	- 21	4563.99	58.87	- 2	4558.85	
...	...	...	...	...	...	3-4	n B	46.5230	4564.90	- 21	4564.69	60.23	- 2	4560.21	
1	n D	48.6107	4567.21	+ 5	4567.26	5	D	46.5964	4565.99	- 20	4565.79	62.29	- 2	4562.27	
2	n B	48.6497	4567.80	+ 5	4567.85	2	D	46.6857	4567.33	- 20	4567.13	63.58	- 2	4563.56	
1	n B	48.8192	4570.34	+ 5	4570.39	3	B	46.7274	4567.95	- 20	4567.75	64.70	- 2	4564.68	
...	...	...	...	...	...	3	B	46.8945	4570.45	- 19	4570.26	65.87	- 2	4565.85	
...	...	...	...	...	...	2	D	47.3845	4577.85	- 16	4577.69	67.20	- 2	4567.18	
...	...	...	...	...	...	1-2	B	47.4429	4578.74	- 16	4578.58	67.74	- 2	4567.72	
1	n D	49.4009	4579.16	+ 7	4579.23	2	D	47.4832	4579.35	- 16	4579.19	70.33	- 2	4570.31	
2	n D	49.4940	4580.59	+ 7	4580.66	1-2	B	47.5162	4579.85	- 16	4579.69	70.96	- 2	4570.9	
...	...	...	...	...	...	4	D	47.5667	4580.62	- 15	4580.47	77.69	- 2	4577.67	
...	...	...	...	...	...	2	B	47.6152	4581.36	- 15	4581.21	78.42	- 2	4578.4	
...	...	...	...	...	...	1	B	47.7889	4584.01	- 13	4583.88	78.78	- 2	4578.76	
...	...	...	...	...	...	n D	47.8447	4584.86	- 12	4584.74	79.21	- 2	4579.19		
2	n D	47.9517	4586.50	- 11	4586.39	2	D	47.9517	4586.50	- 11	4586.39	79.69	- 2	4579.67	
...	...	...	...	...	...	2	B	48.1270	4589.19	- 10	4589.09	80.52	- 2	4580.50	
...	...	...	...	...	...	3	D	48.1742	4589.92	- 10	4589.82	81.37	- 2	4581.35	
...	...	...	...	...	...	1	n B	48.2210	4590.65	- 9	4590.56	82.96	- 2	4582.94	
2	nn D	50.1904	4591.30	+ 9	4591.39	2	D	48.2588	4591.23	- 8	4591.15	83.88	- 2	4583.86	
1-2	n B	50.2325	4591.95	+ 9	4592.04	3	B	48.3040	4591.93	- 8	4591.85	84.74	- 2	4584.72	
...	...	...	...	...	...	4-5	D	48.4403	4594.03	- 8	4593.95	86.39	- 2	4586.37	
...	...	...	...	...	...	B {	from	48.4810	4594.70	- 7	4594.63	88.95	- 2	4588.9	
...	...	...	...	...	...	4	to	48.5650	4596.00	- 7	4595.93	89.09	- 2	4589.07	
...	...	...	...	...	...	1	n D	48.6163	4596.77	- 6	4596.71	89.86	- 2	4589.84	
...	...	...	...	...	...	1	D	48.6999	4597.64	- 6	4597.58	90.56	- 2	4590.54	
...	...	...	...	...	...	...	...	...	...	...	...	91.27	- 2	4591.25	
...	...	...	...	...	...	...	...	...	...	...	...	91.95	- 2	4591.93	
...	...	...	...	...	...	...	...	...	...	...	...	93.17	- 2	4593.2	
...	...	...	...	...	...	...	...	...	...	...	...	93.95	- 2	4593.93	
...	...	...	...	...	...	...	...	...	...	...	...	94.63	- 2	4594.6	
...	...	...	...	...	...	...	...	...	...	...	...	95.41	- 2	4595.42	
...	...	...	...	...	...	...	...	...	...	...	...	95.93	- 2	4595.9	
...	...	...	...	...	...	...	...	...	...	...	...	96.71	- 2	4596.69	
...	...	...	...	...	...	...	...	...	...	...	...	97.39	- 2	4597.37	
...	...	...	...	...	...	...	...	...	...	...	...	99.24	- 2	4599.22	
...	...	...	...	...	...	...	...	...	...	...	...	00.91	- 2	4600.89	
...	...	...	...	...	...	1	n B	48.9722	4602.32	- 3	4602.29	02.29	- 2	4602.27	
...	...	...	...	...	...	nn D	49.0083	4602.88	- 3	4602.85	02.85	- 2	4602.83		
...	...	...	...	...	...	wn D	49.2316	4606.39	0	4606.39	06.39	- 2	4606.37		
...	...	...	...	...	...	...	n D	49.3930	4608.93	+ 1	4608.94	08.94	- 2	4608.92	
...	...	...	...	...	...	2	D	49.5517	4611.44	+ 2	4611.46	11.46	- 2	4611.44	
...	...	...	...	...	...	2	B	49.5840	4611.95	+ 2	4611.97	12.25	- 2	4612.23	
...	...	...	...	...	...	3	D	49.7190	4614.10	+ 4	4614.14	13.95	- 2	4613.93	
...	...	...	...	...	...	...	...	...	...	...	...	15.16	- 2	4615.14	
4	B	51.8908	4618.08	+ 16	4618.24	8	w D	49.8564	4616.28	+ 4	4616.32	16.44	- 2	4616.42	
3-4	D	51.9645	4619.23	+ 16	4619.39	5	B	49.9700	4618.10	+ 5	4618.15	18.17	- 2	4618.15	
...	...	...	...	...	...	4-5	n D	50.0348	4619.13	+ 5	4619.18	19.42	- 2	4619.40	
...	...	...	...	...	...	...	...	...	...	...	...	22.49	- 2	4622.47	
...	...	...	...	...	...	...	...	...	...	...	...	25.73	- 2	4625.71	
1	n B	52.5785	4629.18	+ 18	4629.36	...	...	...	...	...	...	29.36	- 2	4629.34	
...	...	...	...	...	...	...	...	...	...	...	...	38.09	- 2	4638.07	

## 152 SCHJELLERUP—Continued

PLATE G 386						PLATE G 391					
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length
		mm.	mm.		mm.			mm.	mm.		mm.
1	B	47.7009	4639.22	-21	4639.01	3	B	50.7557	4639.39	-24	4639.15
5 G	D	47.7045	4640.82	-20	4640.62	4-5	D	50.6933	4641.01	-24	4640.77
	No details in blue band										
	w D	44.1820	4736.50	+8	4736.58						
	from	44.1180	4738.35	+8	4738.43						
B	to	44.0790	4739.47	+8	4739.55	0-1	B	47.1154	4739.50	-2	4739.48
	to	44.0160	4741.30	+8	4741.38						
	from	43.8840	4745.12	+10	4745.22	D	from	47.0840	4740.42	-2	4740.40
B	to	43.8340	4746.58	+10	4746.68		to	46.9020	4745.76	-1	4745.75
	to	43.7430	4749.24	+11	4749.35	Max	B	46.8439	4747.46	-1	4747.45
	w D	43.6758	4751.19	+11	4751.30		to	46.7800	4749.34	0	4749.34
	Head	43.6242	4752.70	+11	4752.81		w D	46.7093	4751.43	0	4751.43
							Head	46.6466	4753.29	0	4753.29
							wn D	46.4400	4759.18	+1	4759.19
Max	B	43.3482	4760.84	+13	4760.97	2	B	46.3903	4760.93	+1	4760.94
Max	B	42.8738	4775.01	+16	4775.17	3	n B	45.9100	4775.43	+3	4775.46
						1	n D	45.8620	4776.89	+3	4776.92
						1	n D	45.7700	4779.70	+3	4779.73
						2	n B	45.6740	4782.64	+3	4782.67
Max	B	42.3345	4791.39	+18	4791.57	2	n B	45.3800	4791.71	+4	4791.75
Max	B	42.2206	4795.80	+18	4796.07	3	n B	45.2900	4795.44	+4	4795.48
1-2	n D	41.5465	4815.91	+20	4816.11	2	nn D	44.5980	4816.28	+5	4816.33
1	B	41.3355	4822.59	+20	4822.79						
1 2	nn D	41.3007	4823.69	+20	4823.89						
1 5	B	41.2325	4825.87	+20	4826.07	4	n B	44.2948	4825.99	+5	4826.04
2 3	n D	41.1665	4827.97	+20	4828.17	2	n D	44.2250	4828.24	+5	4828.29
5	B	41.0973	4830.19	+20	4830.39	4	n B	44.1494	4830.68	+5	4830.73
4	n D	41.0302	4832.34	+20	4832.54	5	D	44.0887	4832.65	+5	4832.70
1-2	nn D	40.6867	4843.45	+19	4843.64	1 2	n D	43.7565	4843.49	+5	4843.54
1	B	40.6368	4845.07	+18	4845.25						
1	n D	40.4305	4851.82	+17	4851.96						
1	n D	40.3055	4855.93	+17	4856.10						
						2 3	B	43.3169	4858.03	+4	4858.07
1	n D	40.2020	4859.36	+16	4859.52	1	nn D	43.2059	4859.74	+4	4859.78

## 152 SCHJELLERUP—Continued

PLATE A 313						PLATE A 319						MEAN WAVE-LENGTH		
Intensity	Character	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Intensity	Character	Mean Scale Reading	Wave-length by Formula	Cor. from Curve	Wave-length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity
1	nB	53.1800	4639.01	+20	4639.21	...	nB	51.2564	4638.58	+16	4638.74	38.98	-2	4638.96
...	nnD	53.2447	4640.07	+20	4640.27	...	wD	51.3495	4640.44	+17	4640.61	40.57	-2	4640.55
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	36.58	-2	4736.6
...	...	...	...	...	...	...	...	...	...	...	...	38.43	-2	4738.4
...	...	...	...	...	...	...	...	...	...	...	...	39.52	-2	4739.50
...	...	...	...	...	...	...	...	...	...	...	...	41.38	-2	4741.3
...	...	...	...	...	...	...	...	...	...	...	...	40.40	-2	4740.4
...	...	...	...	...	...	...	...	...	...	...	...	45.49	-2	4745.4
...	...	...	...	...	...	...	...	...	...	...	...	47.07	-2	4747.05
...	...	...	...	...	...	...	...	...	...	...	...	49.35	-2	4749.3
10	D	59.5727	4751.44	+35	4751.79	...	wD	57.6313	4750.76	+55	4751.31	51.61	-2	4751.59
...	Head	59.6444	4752.79	+35	4753.14	...	Head	57.7213	4752.45	+56	4753.01	53.08	-2	4753.06
1	nD	59.8052	4755.82	+36	4756.18	2	nB	57.8319	4754.53	+56	4755.09	55.09	-2	4755.07
...	...	...	...	...	...	...	nD	57.8842	4755.52	+56	4756.08	56.13	-2	4756.11
4	B	59.8510	4756.69	+36	4757.05	4	nB	57.9359	4756.50	+56	4757.06	57.06	-2	4757.04
3	nD	59.9817	4759.17	+36	4759.53	1	nD	58.0577	4758.80	+56	4759.36	59.36	-2	4759.34
...	wnB	60.0465	4760.40	+36	4760.76	4	wnB	58.1228	4760.04	+57	4760.61	60.82	-2	4760.80
2	D	60.1305	4762.00	+36	4762.36	...	...	...	...	...	...	62.36	-2	4762.34
3	nB	60.1845	4763.03	+36	4763.39	3	B	58.2691	4762.82	+57	4763.39	63.39	-2	4763.37
...	nnD	60.2373	4764.03	+36	4764.39	1	nD	58.3085	4763.57	+57	4764.14	64.27	-2	4764.45
3	nB	60.2969	4765.17	+36	4765.53	...	...	...	...	...	...	65.47	-2	4765.45
2 3	nD	60.3575	4766.33	+36	4766.69	1	nD	58.4280	4765.85	+57	4766.42	66.56	-2	4766.54
...	...	...	...	...	...	2	nB	58.5080	4767.38	+58	4767.96	67.96	-2	4767.94
1	nD	60.4615	4768.32	+36	4768.68	...	...	...	...	...	...	68.68	-2	4768.66
...	...	...	...	...	...	1	nB	58.5907	4768.96	+58	4769.54	69.60	-2	4769.58
3	nB	60.7943	4774.73	+36	4775.09	5	nB	58.8769	4774.47	+59	4775.06	75.20	-2	4775.18
2	nD	60.8794	4776.38	+37	4776.75	...	...	...	...	...	...	76.84	-2	4776.82
...	...	...	...	...	...	1	nB	59.0264	4777.36	+59	4777.95	77.95	-2	4777.93
...	nnD	61.0210	4779.12	+37	4779.49	...	...	...	...	...	...	79.61	-2	4779.59
Max	B	61.1822	4782.26	+37	4782.63	4	nB	59.2639	4781.97	+60	4782.57	82.62	-2	4782.60
1	nD	61.2984	4784.52	+37	4784.89	...	...	...	...	...	...	84.86	-2	4784.84
...	nD	61.3982	4786.48	+37	4786.85	...	...	...	...	...	...	86.85	-2	4786.83
...	nnD	61.5374	4789.21	+37	4789.58	1-2	nD	59.6324	4789.18	+60	4789.78	89.68	-2	4789.66
...	...	...	...	...	...	...	nnD	59.7952	4792.37	+60	4792.97	91.66	-2	4791.64
...	...	...	...	...	...	...	...	...	...	...	...	92.97	-2	4792.95
...	nnD	62.0592	4799.52	+37	4799.89	...	...	...	...	...	...	95.78	-2	4799.76
1	nD	62.2115	4802.55	+37	4802.92	...	...	...	...	...	...	99.89	-2	4799.87
...	nnD	62.3107	4804.53	+37	4804.90	1	nD	60.3925	4804.23	+62	4804.85	04.88	-2	4804.86
...	nnD	62.4029	4806.37	+37	4806.74	1	nD	60.4774	4805.91	+62	4806.53	06.64	-2	4806.62
...	nnD	62.8620	4815.62	+37	4815.99	1	nD	60.9689	4815.80	+62	4816.42	16.17	-2	4816.15
...	nnD	63.2535	4823.57	+37	4823.94	2	nD	61.3327	4823.19	+62	4823.81	23.88	-2	4823.86
B	from	63.2930	4824.38	+37	4824.75	...	B	61.4160	4824.89	+62	4825.51	24.75	-2	4824.7
...	to	63.3985	4826.54	+37	4826.91	...	...	...	...	...	...	25.87	-2	4825.85
2	nD	63.4327	4827.24	+37	4827.61	1	nD	61.5210	4827.04	+62	4827.66	26.91	-2	4826.9
2 3	nB	63.5830	4830.32	+37	4830.69	6	nB	61.6592	4829.87	+62	4830.49	30.58	-2	4830.56
5	nD	63.6652	4832.02	+37	4832.39	6	D	61.7464	4831.67	+62	4832.29	32.48	-2	4832.46
Con.	from	63.7715	4834.21	+37	4834.58	...	...	...	...	...	...	34.58	-2	4834.6
Spec.	to	64.1420	4841.90	+37	4842.27	0	nD	62.0692	4838.34	+61	4838.95	38.95	-2	4838.93
...	nnD	64.2053	4843.22	+37	4843.59	2	nD	62.2755	4842.63	+61	4843.24	42.27	-2	4842.3
2	nD	64.2782	4844.74	+37	4845.11	...	...	...	...	...	...	43.50	-2	4843.48
Con.	from	64.3135	4845.48	+36	4845.84	...	...	...	...	...	...	45.18	-2	4845.16
Spec.	to	64.5650	4850.75	+36	4851.11	...	...	...	...	...	...	45.84	-2	4845.8
...	nnD	64.5997	4851.48	+36	4851.84	...	...	...	...	...	...	51.11	-2	4851.1
...	...	...	...	...	...	...	...	...	...	...	...	51.93	-2	4851.91
Con.	from	64.8325	4856.39	+36	4856.75	...	...	...	...	...	...	56.10	-2	4856.08
...	...	...	...	...	...	...	...	...	...	...	...	56.75	-2	4856.7
Spec.	to	64.9455	4858.79	+36	4859.15	...	...	...	...	...	...	58.07	-2	4858.05
1	nD	64.9647	4859.20	+36	4859.56	...	...	...	...	...	...	59.15	-2	4859.1
1 2	nB	65.0206	4860.38	+36	4860.74	...	...	...	...	...	...	59.67	-2	4859.65
...	...	...	...	...	...	...	...	...	...	...	...	60.74	-2	4860.72

152 SCHJELLERUP *Continued*

PLATE G 316						PLATE G 394					
Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length	Inten- sity	Char- acter	Mean Scale Reading	Wave- Length by Formula	Cor. from Curve	Wave- Length
		mm.	Å.		Å.			mm.	Å.		Å.
1	n D	40.1160	4862.22	+16	4862.38	1	n D	43.1853	4862.43	+ 4	4862.47
1	n D	40.0289	4865.10	+15	4865.25	1	n D	43.1040	4865.16	+ 3	4865.19
1	.....	.....	.....	.....	.....	1	nn D	43.0128	4868.23	+ 3	4868.26
4	D	39.8491	4871.11	+14	4871.25	4	D	42.9122	4871.63	+ 3	4871.66
2	D	39.7203	4875.44	+13	4875.57	1	D	42.7174	4878.25	+ 2	4878.27
1	D	39.6320	4878.42	+12	4878.54	4	w D	42.6121	4881.84	+ 2	4881.86
2	B	39.6013	4879.46	+12	4879.58	3	B	42.5533	4883.86	+ 2	4883.88
5	D	39.5428	4881.44	+12	4881.56	6	w D	42.4864	4886.16	+ 1	4886.17
5	B	39.4800	4883.57	+12	4883.69	2	B	42.4250	4888.27	+ 1	4888.28
3 4	D	39.4144	4885.80	+11	4885.91	.....	from	42.3120	4892.18	+ 1	4892.19
.....	.....	.....	.....	.....	.....	B	.....	.....	.....	.....	.....
3 4	B	39.1854	4893.64	+ 9	4893.73	3	to	42.0790	4900.28	0	4900.28
0 8	w B	39.0383	4898.71	+ 9	4898.80	.....	D	42.0420	4901.56	0	4901.56
3	D	38.9761	4900.86	+ 8	4900.94	4	w B	41.9713	4904.04	- 1	4904.03
7	B	38.8935	4903.73	+ 7	4903.80	3	w D	41.8992	4906.57	- 1	4906.56
4	n D	38.8123	4906.55	+ 6	4906.61	4	w D	41.7683	4911.18	- 2	4911.16
2	n D	38.7063	4910.25	+ 5	4910.30	1-2	n D	41.3203	4927.13	- 4	4927.06
4-5	nn D	38.4139	4920.54	+ 2	4920.56	1-2	n B	41.2587	4929.34	- 5	4929.29
.....	.....	.....	.....	.....	.....	1	n D	40.8027	4945.89	- 7	4945.82
2	n B	37.7610	4943.91	- 5	4943.86	.....	.....	.....	.....	.....	.....
1-2	nn D	37.7064	4945.90	- 7	4945.83	.....	.....	.....	.....	.....	.....
1-2	B	37.6511	4947.90	- 7	4947.83	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	B	37.5382	4952.03	- 9	4951.94	.....	.....	.....	.....	.....	.....
1	n D	37.4760	4954.30	-10	4954.20	2	n D	40.5741	4954.30	- 9	4954.21
2	n D	37.3805	4957.81	-11	4957.70	.....	.....	.....	.....	.....	.....
End	.....	36.8590	4977.2	-19	4977.0	End	.....	39.9740	4976.8	-13	4976.7

## 152 SCHJELLERUP—Continued

PLATE A 313						PLATE A 319						MEAN WAVE-LENGTH			
Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Intensity	Character	Mean Scale Reading	Wave-Length by Formula	Cor. from Curve	Wave-Length	Uncorrected for Velocity	Cor. for V	Corrected for Velocity	
		mm.	t.m.		t.m.			mm.	t.m.		t.m.			t.m.	
...	nn D	65.0867	4861.79	+36	4862.15	...	...	...	...	...	...	62.31	-2	4862.29	
...	nn D	65.2159	4864.55	+35	4864.90	...	...	...	...	...	...	65.11	-2	4865.09	
...	nn D	65.3530	4867.48	+35	4867.83	...	nn D	63.4397	4867.23	+57	4867.80	67.96	-2	4867.94	
3	wn D	65.5204	4871.07	+34	4871.41	3	n B	63.4955	4868.42	+57	4868.99	68.99	-2	4869.07	
2	n D	65.7120	4875.20	+34	4875.54	...	nn D	63.5905	4870.46	+57	4871.03	71.34	-2	4871.32	
1-2	nn D	65.8364	4877.89	+33	4878.22	...	nn D	63.7809	4874.57	+56	4875.13	75.35	-2	4875.33	
5-6	n B	65.9035	4879.35	+33	4879.68	4	n B	63.9845	4878.97	+56	4879.53	79.63	-2	4879.61	
2-3	n B	65.9855	4881.13	+33	4881.46	7	D	64.0649	4880.72	+55	4881.27	81.54	-2	4881.52	
	n B	66.0672	4882.91	+33	4883.24	5	n B	64.1542	4882.66	+55	4883.21	83.51	-2	4883.49	
	from	66.1160	4884.20	+32	4884.52	...	...	...	...	...	...	84.52	-2	4884.5	
D	to	66.2525	4886.95	+32	4887.27	3 4	D	64.2942	4885.28	+54	4885.82	85.97	-2	4885.95	
2-3	n B	66.2853	4887.67	+32	4887.99	4	n B	64.3655	4887.27	+54	4887.81	88.06	-2	4887.3	
Con.	nn D	66.3480	4889.00	+32	4889.32	1	n D	64.5034	4890.30	+53	4890.83	90.1	-2	4889.04	
	from	66.4660	4891.60	+32	4891.92	...	...	...	...	...	...	92.06	-2	4892.0	
Spec.	to	66.6240	4895.10	+31	4895.41	...	...	...	...	...	...	93.73	-2	4893.71	
3-4	n B	66.7787	4898.53	+31	4898.84	4	B	64.8534	4898.02	+51	4898.53	95.41	-2	4895.4	
...	wn D	66.8780	4900.73	+31	4901.04	3	n D	64.9767	4900.75	+50	4901.25	98.72	-2	4898.70	
B	from	66.9325	4901.95	+30	4902.25	5	n B	65.0814	4903.08	+49	4903.57	00.28	-2	4900.3	
...	to	67.0510	4904.58	+30	4904.88	...	...	...	...	...	...	02.25	-2	4902.2	
3	wn D	67.1070	4905.83	+30	4906.13	...	...	...	...	...	...	03.80	-2	4903.78	
3	n B	67.2142	4908.23	+29	4908.52	3-4	B	65.2967	4907.89	+47	4908.36	04.88	-2	4904.9	
3	n D	67.3092	4910.36	+29	4910.65	nn D	65.3838	4909.84	+47	4910.31	06.43	-2	4906.41		
...	...	...	...	...	...	...	wn D	66.1150	4926.39	+40	4926.79	08.44	-2	4908.42	
2	n B	68.1255	4928.85	+26	4929.11	2	n B	66.2062	4928.47	+39	4928.86	10.61	-2	4910.59	
...	nn D	68.1936	4930.43	+26	4930.69	2	n D	66.3024	4930.67	+38	4931.05	20.56	-2	4920.54	
...	nn D	68.8315	4945.13	+23	4945.36	2	n D	66.9292	4945.16	+32	4945.48	26.94	-2	4926.92	
...	...	...	...	...	...	...	2	n D	67.0518	4948.02	+31	4948.33	29.09	-2	4929.07
...	nn D	69.0174	4949.47	+22	4949.69	3	n D	67.1088	4949.32	+30	4949.62	30.87	-2	4930.85	
...	nn D	69.1897	4953.50	+21	4953.71	1	n D	67.2804	4953.37	+28	4953.65	43.86	-2	4943.84	
End	...	70.1385	4976.03	+16	4976.19	End	...	68.2360	4976.10	+16	4976.3	45.62	-2	4945.60	
												47.83	-2	4947.81	
												48.39	-2	4948.37	
												49.66	-2	4949.64	
												51.88	-2	4951.86	
												53.94	-2	4953.92	
												57.70	-2	4957.68	

## 152 SCHJELLERUP

PLATE G 175  
1869, January 14, 6 M.T. 22.2  
Hourly motion E 1/8 S  
Star extended; diameter 17.5 sec. 2000

[illegible]

PLATE G 294  
1899, January 26, G.M.T. 2048  
Star good; comparison good

PLATE G 202

1899, March 6, G.M.T. 22h8

Hour angle, W 203

Star excellent; comparison good

MEAN  
WAVE-LENGTH

Intensity	Chirp factor	Mean Scale Reading	Wave Length by Form		Wave Length by Curve		Wave Length by Curve	Wave Length by Curve	Con- stant, Volts	Con- stant, Volts	Con- stant, Volts	Con- stant, Volts	Con- stant, Volts
			m.m.	m.m.	m.m.	m.m.							
Head			50.5000	5167.65	50.5000	5167.65	50.5000	5167.65	67.88	67.88	67.88	67.88	67.88
1	n D	50.7104	5169.45	5	5169.45	50.7104	5169.45	50.7104	68.72	68.72	68.72	68.72	68.72
3	B	50.6802	5170.60	15	5170.60	50.6802	5170.60	50.6802	70.77	70.77	70.77	70.77	70.77
5	D	50.6199	5173.00	45	5173.00	50.6199	5173.00	50.6199	73.29	73.29	73.29	73.29	73.29
7	B	50.5835	5175.00	14	5175.00	50.5835	5175.00	50.5835	75.45	75.45	75.45	75.45	75.45
9	D	50.5511	5176.80	34	5176.80	50.5511	5176.80	50.5511	77.00	77.00	77.00	77.00	77.00
11	B	50.5140	5178.91	12	5178.91	50.5140	5178.91	50.5140	81.10	81.10	81.10	81.10	81.10
13	D	50.4784	5181.39	9	5181.39	50.4784	5181.39	50.4784	83.38	83.38	83.38	83.38	83.38
15	B	50.4520	5183.88	11	5183.88	50.4520	5183.88	50.4520	84.11	84.11	84.11	84.11	84.11
17	D	50.4202	5186.80	30	5186.80	50.4202	5186.80	50.4202	85.30	85.30	85.30	85.30	85.30
19	B	50.3914	5189.25	19	5189.25	50.3914	5189.25	50.3914	86.32	86.32	86.32	86.32	86.32
21	D	50.3644	5191.43	10	5191.43	50.3644	5191.43	50.3644	87.05	87.05	87.05	87.05	87.05
23	nn D	50.3409	5193.41	7	5193.41	50.3409	5193.41	50.3409	87.87	87.87	87.87	87.87	87.87
25	B	50.3180	5195.74	8	5195.74	50.3180	5195.74	50.3180	88.32	88.32	88.32	88.32	88.32
27	D	50.2984	5198.27	14	5198.27	50.2984	5198.27	50.2984	88.72	88.72	88.72	88.72	88.72
29	B	50.2804	5200.91	15	5200.91	50.2804	5200.91	50.2804	89.08	89.08	89.08	89.08	89.08
31	D	50.2640	5203.65	22	5203.65	50.2640	5203.65	50.2640	89.40	89.40	89.40	89.40	89.40
33	B	50.2490	5206.49	21	5206.49	50.2490	5206.49	50.2490	89.68	89.68	89.68	89.68	89.68
35	D	50.2354	5209.43	29	5209.43	50.2354	5209.43	50.2354	89.92	89.92	89.92	89.92	89.92
37	B	50.2230	5212.47	24	5212.47	50.2230	5212.47	50.2230	90.13	90.13	90.13	90.13	90.13
39	D	50.2116	5215.61	33	5215.61	50.2116	5215.61	50.2116	90.30	90.30	90.30	90.30	90.30
41	B	50.2012	5218.85	32	5218.85	50.2012	5218.85	50.2012	90.44	90.44	90.44	90.44	90.44
43	D	50.1916	5222.20	40	5222.20	50.1916	5222.20	50.1916	90.55	90.55	90.55	90.55	90.55
45	B	50.1836	5225.65	35	5225.65	50.1836	5225.65	50.1836	90.63	90.63	90.63	90.63	90.63
47	D	50.1762	5229.20	43	5229.20	50.1762	5229.20	50.1762	90.68	90.68	90.68	90.68	90.68
49	B	50.1694	5232.85	4	5232.85	50.1694	5232.85	50.1694	90.72	90.72	90.72	90.72	90.72
51	D	50.1626	5236.50	51	5236.50	50.1626	5236.50	50.1626	90.74	90.74	90.74	90.74	90.74
53	B	50.1568	5240.15	50	5240.15	50.1568	5240.15	50.1568	90.76	90.76	90.76	90.76	90.76
55	D	50.1500	5243.80	59	5243.80	50.1500	5243.80	50.1500	90.78	90.78	90.78	90.78	90.78
57	B	50.1442	5247.45	58	5247.45	50.1442	5247.45	50.1442	90.79	90.79	90.79	90.79	90.79
59	D	50.1384	5251.10	67	5251.10	50.1384	5251.10	50.1384	90.80	90.80	90.80	90.80	90.80
61	B	50.1326	5254.75	66	5254.75	50.1326	5254.75	50.1326	90.81	90.81	90.81	90.81	90.81
63	D	50.1268	5258.40	75	5258.40	50.1268	5258.40	50.1268	90.82	90.82	90.82	90.82	90.82
65	B	50.1210	5262.05	74	5262.05	50.1210	5262.05	50.1210	90.83	90.83	90.83	90.83	90.83
67	D	50.1152	5265.70	83	5265.70	50.1152	5265.70	50.1152	90.84	90.84	90.84	90.84	90.84
69	B	50.1094	5269.35	82	5269.35	50.1094	5269.35	50.1094	90.85	90.85	90.85	90.85	90.85
71	D	50.1036	5273.00	91	5273.00	50.1036	5273.00	50.1036	90.86	90.86	90.86	90.86	90.86
73	B	50.0978	5276.65	90	5276.65	50.0978	5276.65	50.0978	90.87	90.87	90.87	90.87	90.87
75	D	50.0920	5280.30	99	5280.30	50.0920	5280.30	50.0920	90.88	90.88	90.88	90.88	90.88
77	B	50.0862	5283.95	98	5283.95	50.0862	5283.95	50.0862	90.89	90.89	90.89	90.89	90.89
79	D	50.0804	5287.60	107	5287.60	50.0804	5287.60	50.0804	90.90	90.90	90.90	90.90	90.90
81	B	50.0746	5291.25	106	5291.25	50.0746	5291.25	50.0746	90.91	90.91	90.91	90.91	90.91
83	D	50.0688	5294.90	115	5294.90	50.0688	5294.90	50.0688	90.92	90.92	90.92	90.92	90.92
85	B	50.0630	5298.55	114	5298.55	50.0630	5298.55	50.0630	90.93	90.93	90.93	90.93	90.93
87	D	50.0572	5302.20	123	5302.20	50.0572	5302.20	50.0572	90.94	90.94	90.94	90.94	90.94
89	B	50.0514	5305.85	122	5305.85	50.0514	5305.85	50.0514	90.95	90.95	90.95	90.95	90.95
91	D	50.0456	5309.50	131	5309.50	50.0456	5309.50	50.0456	90.96	90.96	90.96	90.96	90.96
93	B	50.0398	5313.15	130	5313.15	50.0398	5313.15	50.0398	90.97	90.97	90.97	90.97	90.97
95	D	50.0340	5316.80	139	5316.80	50.0340	5316.80	50.0340	90.98	90.98	90.98	90.98	90.98
97	B	50.0282	5320.45	138	5320.45	50.0282	5320.45	50.0282	90.99	90.99	90.99	90.99	90.99
99	D	50.0224	5324.10	147	5324.10	50.0224	5324.10	50.0224	91.00	91.00	91.00	91.00	91.00
101	B	50.0166	5327.75	146	5327.75	50.0166	5327.75	50.0166	91.01	91.01	91.01	91.01	91.01
103	D	50.0108	5331.40	155	5331.40	50.0108	5331.40	50.0108	91.02	91.02	91.02	91.02	91.02
105	B	50.0050	5335.05	154	5335.05	50.0050	5335.05	50.0050	91.03	91.03	91.03	91.03	91.03
107	D	50.0000	5338.70	163	5338.70	50.0000	5338.70	50.0000	91.04	91.04	91.04	91.04	91.04
109	B	50.0000	5342.35	162	5342.35	50.0000	5342.35	50.0000	91.05	91.05	91.05	91.05	91.05
111	D	50.0000	5346.00	171	5346.00	50.0000	5346.00	50.0000	91.06	91.06	91.06	91.06	91.06
113	B	50.0000	5349.65	170	5349.65	50.0000	5349.65	50.0000	91.07	91.07	91.07	91.07	91.07
115	D	50.0000	5353.30	179	5353.30	50.0000	5353.30	50.0000	91.08	91.08	91.08	91.08	91.08
117	B	50.0000	5356.95	178	5356.95	50.0000	5356.95	50.0000	91.09	91.09	91.09	91.09	91.09
119	D	50.0000	5360.60	187	5360.60	50.0000	5360.60	50.0000	91.10	91.10	91.10	91.10	91.10
121	B	50.0000	5364.25	186	5364.25	50.0000	5364.25	50.0000	91.11	91.11	91.11	91.11	91.11
123	D	50.0000	5367.90	195	5367.90	50.0000	5367.90	50.0000	91.12	91.12	91.12	91.12	91.12
125	B	50.0000	5371.55	194	5371.55	50.0000	5371.55	50.0000	91.13	91.13	91.13	91.13	91.13
127	D	50.0000	5375.20	203	5375.20	50.0000	5375.20	50.0000	91.14	91.14	91.14	91.14	91.14
129	B	50.0000	5378.85	202	5378.85	50.0000	5378.85	50.0000	91.15	91.15	91.15	91.15	91.15
131	D	50.0000	5382.50	211	5382.50	50.0000	5382.50	50.0000	91.16	91.16	91.16	91.16	91.16
133	B	50.0000	5386.15	210	5386.15	50.0000	5386.15	50.0000	91.17	91.17	91.17	91.17	91.17
135	D	50.0000	5389.80	219	5389.80	50.0000	5389.80	50.0000	91.18	91.18	91.18	91.18	91.18
137	B	50.0000	5393.45	218	5393.45	50.0000	5393.45	50.0000	91.19	91.19	91.19	91.19	91.19
139	D	50.0000	5397.10	227	5397.10	50.0000	5397.10	50.0000	91.20	91.20	91.20	91.20	91.20
141	B	50.0000	5400.75	226	5400.75	50.0000	5400.75	50.0000	91.21	91.21	91.21	91.21	91.21
143	D	50.0000	5404.40	235	5404.40	50.0000	5404.40	50.0000	91.22	91.22	91.22	91.22	91.22
145	B	50.0000	5408.05	234	5408.05	50.0000	5408.05	50.0000	91.23	91.23	91.23	91.23	91.23
147	D	50.0000	5411.70	243	5411.70	50.0000	5411.70	50.0000	91.24	91.24	91.24	91.24	91.24
149	B	50.0000	5415.35	242	5415.35	50.0000	5415.35	50.0000	91.25	91.25	91.25	91.25	91.25
151	D	50.0000	5419.00	251	5419.00	50.0000	5419.00	50.0000	91.26	91.26	91.26	91.26	91.26
153	B	50.0000	5422.65	250	5422.65	50.0000	5422.65	50.0000	91.27	91.27	91.27	91.27	91.27
155	D	50.0000	5426.30	259	5426.30	50.0000	5426.30	50.0000	91.28	91.28	91.28	91.28	91.28
157	B	50.0000	5429.95	258	5429.95	50.0000	5429.95	50.0000	91.29	91.29	91.29	91.29	91.29
159	D	50.0000	5433.60	267	5433.60	50.0000	5433.60	50.0000	91.30	91.30	91.30	91.30	91.30
161	B	50.0000	5437.25	266	5437.25	50.0000	5437.25	50.0000	91.31	91.31	91.31	91.31	91.31
163	D	50.0000	5440.90	275	5440.90	50.0000	5440.90	50.0000	91.32	91.32	91.32	91.32	91.32
165	B	50.0000	5444.55	274	5444.5								



## DETERMINATION OF THE RADIAL VELOCITIES

The determination of the radial velocities was complicated by the presence of bright lines in the spectra, since the apparent center of a neighboring dark line would be shifted by an amount which would vary with the exposure and consequent density of the negative. To avoid this difficulty as far as possible, dark lines away from bright lines were selected for velocity determinations whenever they were available. The following tables give in detail for each star the lines selected, the elements with which they were identified, the differences in wave-length, and the resulting velocity corrections. The great range for the different lines is partly due to the cause just mentioned, but errors also necessarily arise from the use of lines which blend together in the spectra of these stars, though they are well separated in the solar spectrum. Such blends result from the large slit-widths used with comparatively small dispersion, the increased strength of lines in fourth-type spectra, and the changes of relative intensity as compared with the solar spectrum.

## RADIAL VELOCITIES FROM THE DARK LINES

The tables are arranged as follows: The third column, headed  $\Delta\lambda$ , gives the displacement of the lines in hundredths of a tenth-meter; the fourth column gives the velocity corresponding to a displacement of one tenth-meter; the fifth column gives the deduced velocity, being the product of columns three and four.

## 16 PISCUM

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4404.95	Fe 04.94	+ 1	68	+ 1
4408.48	Fe 08.60	-12	68	- 8
4415.14	Fe 15.33	-19	68	-13
4489.72	Fe 89.10	-18	67	-12
4496.99	Cr 97.02	- 3	67	- 2
4512.73	Ti 12.91	-18	66	-12
4518.24	Ti 18.18	+ 6	66	+ 4
4522.97	Ti 22.97	0	66	0
4594.31	V 94.27	+ 4	66	+ 3
4789.40	Fe 89.40 du	0	63	0
5247.53	Fe 47.27	+26	57	+15
5397.54	Fe 97.70 tr	-26	56	-14
5406.39	Fe 05.98	+41	55	+22
5430.35	Fe 29.81	+54	55	+30
5731.16	Fe 31.98	-82	52	-43

16 lines, Mean -2 km.

## 318 BIRMINGHAM

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4405.00	Fe 04.94	- 6	68	- 4
4414.96	Fe 15.33	-37	68	-25
4496.82	Cr 97.02	-20	67	-13
4512.49	Ti 12.88	-39	66	-26
4518.16	Ti 18.18	- 2	66	- 1
4522.91	Ti 22.97	- 6	66	- 4
4531.18	Fe 31.31	-13	66	- 9
4920.62	Fe 20.69	- 7	61	- 4
4934.31	Br 34.24	+ 7	61	+ 4
5173.46	Ti 73.94	-48	58	-28
5193.26	Ti 93.15	+11	58	+ 6
5251.10	Ti 50.83	+27	57	+16
5255.42	Ti 55.15	+27	57	+16
5269.84	Ti 69.72	+12	57	+ 7
5297.59	Cr 98.15	-56	57	-32
5328.52	Fe 28.84	+14	56	+ 8
5396.93	Fe 97.32	-39	56	-22
5410.19	Fe 10.53	-34	55	-19

19 lines, Mean -8 km.

## 51 SCHILLERUP

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4444.85	Ti 25.23	-47	68	-32
4512.45	Ti 12.88	-43	66	-29
4517.77	Ti 18.18	-41	66	-27
4522.53	Ti 22.97	-44	66	-29
4905.88	Fe 09.40	-52	65	-34
4945.67	Fe 45.40	-73	64	-47
4997.76	Fe 67.96	-20	64	-13
4981.77	Fe 82.24	-47	64	-30
4714.10	Ni 14.50	-49	61	-31
4728.22	Fe 28.73	-51	63	-32
5297.72	Cr 98.15	-43	57	-25
5349.90	Fe 49.80	+10	56	+ 6
5371.62	Fe 71.68	- 6	56	- 3
5397.62	Fe 97.32	-30	56	-17
5405.81	Fe 05.97	-16	55	- 9
5410.10	Fe 10.52	-12	55	- 7

16 lines, Mean -25 km.

## 51 SCHILLERUP

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4395.13	Ti 95.19	- 6	68	- 4
4415.38	Fe 15.33	+ 5	68	+ 3
4497.29	Cr 97.02	-27	67	-18
4512.43	Ti 12.88	-45	66	-30
4518.46	Ti 18.18	+28	66	+18
4523.23	Ti 22.97	+31	66	+20
4527.45	Ti 27.48	- 3	66	- 2
4565.82	Fe 65.87	- 5	66	- 3
4789.34	Fe 89.37	- 3	63	- 2
4832.65	Fe 32.90	-25	62	-15
5173.31	Mg 72.86	+45	58	+26
5251.76	Fe 51.49	+27	57	+15
5270.17	Fe 70.11	+ 8	57	+ 5

13 lines, Mean +4 km.

78 SCHJELLERUP

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4415.17	Fe 15.33	-16	68	-11
4455.50	Ti 55.48	+2	67	+1
4496.95	Cr 97.02	-7	67	-5
4512.92	Ti 12.88	+4	66	+3
4518.19	Ti 18.18	+1	66	+1
4523.02	Ti 22.97	+5	66	+3
4527.27	{ Ca 27.10	-3	66	-2
	{ Ti 27.49			
4784.52	V 84.65	-13	63	-8
5183.92	Mg 83.79	+15	58	+9
5189.15	Ca 85.05	+10	58	+6
5233.95	V 33.91	+4	57	+2
5349.55	Ca 49.65	-10	56	-6
5731.46	V 31.48	-2	52	-1

13 lines, Mean -1 km.

115 SCHJELLERUP

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4435.28	Fe 35.33	-5	68	-3
4496.84	Cr 97.02	-18	67	-12
4512.85	Ti 12.88	-3	66	-2
4518.01	Ti 18.18	-17	66	-11
4522.88	Ti 22.97	-9	66	-6
4553.89	Ba 54.21	-32	66	-21
5183.38	Mg 83.79	-41	58	-24
5731.72	Fe 31.98	-26	52	-14

8 lines, Mean -12 km.

132 SCHJELLERUP

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4397.83	V 98.35	-35	68	-24
4404.52	Fe 04.94	-42	68	-29
4408.25	Fe 08.60	-35	68	-24
4414.66	Fe 15.33	-67	68	-46
4454.53	Ca 54.95	-42	67	-28
4489.46	Fe 89.90	-44	67	-29
4496.44	Cr 97.02	-58	67	-39
4512.35	Ti 12.88	-53	66	-36
4517.67	Ti 18.18	-51	66	-34
4522.57	Ti 22.97	-40	66	-26
4528.27	Fe 28.84	-57	66	-38
4552.42	Fe 52.72	-30	66	-20
4593.67	V 94.27	-60	65	-39
4656.03	Ti 56.64	-61	64	-39
4924.13	Fe 24.39	-26	61	-16
4933.02	Fe 33.50	-48	61	-29
5172.36	Mg 72.86	-50	58	-29
5246.92	Fe 47.27	-35	57	-19
5297.61	Cr 98.15	-54	57	-31
5328.56	Fe 28.71	-15	56	-9
5397.47	Fe 97.70	-23	56	-13

21 lines, Mean -28 km.

152 SCHJELLERUP

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
4489.63	Fe 89.90	-27	67	-18
4512.83	Ti 12.88	-5	66	-3
4518.25	Ti 18.18	+7	66	+5
4552.67	Fe 52.72	+5	66	+3
4593.95	V 94.27	-32	65	-22
4789.68	Fe 89.80	-12	63	-8

6 lines, Mean, wt. 2, -9 km.

Star	Element	$\Delta\lambda$	$V_1$	$V$
t.m.	t.m.		km.	km.
5173.29	Mg 72.86	+43	58	+25
5202.45	Fe 02.49	-4	58	-2
5247.23	Fe 47.27	-4	57	-2
5270.07	Fe 69.99	+8	57	+5
5328.56	Fe 28.71	-15	56	-8
5430.26	Fe 29.81	+45	55	+25
5686.61	Fe 86.66	-5	53	-3

7 lines, Mean, wt. 1, +6  
Weighted mean, -4 km.

## RADIAL VELOCITIES FROM THE BRIGHT LINES

Comparison with 132 *Schjellerup*

As a check on these very unsatisfactory results, the bright lines of the other stars were compared with the bright lines of 132 *Schjellerup*. The following table gives this comparison, with the velocities resulting from the use of the value -28 km., adopted for 132 *Schjellerup*.

## RADIAL VELOCITIES FROM THE BRIGHT LINES

12 S. ♀.	19 Pisc.		318 Birm.		74 Schj.		78 Schj.		115 Schj.		152 Schj.	
	Δ	ΔΔ	Δ	ΔΔ	Δ	ΔΔ	Δ	ΔΔ	Δ	ΔΔ	Δ	ΔΔ
t.m.	t.m.		t.m.		t.m.		t.m.		t.m.		t.m.	
4402.03	.....	.....	02.32	+29	02.68	+65	.....	.....	.....	.....	.....	.....
4437.05	.....	.....	37.21	+16	.....	.....	.....	.....	.....	.....	.....	.....
4438.45	38.86	+41	38.95	+50	.....	.....	.....	.....	.....	.....	.....	.....
4448.24	.....	.....	48.46	+24	48.95	+71	.....	.....	.....	.....	.....	.....
4403.05	64.01	+36	.....	.....	.....	.....	.....	.....	.....	.....	64.23	+58
4488.29	88.58	+29	.....	.....	.....	.....	.....	.....	.....	.....	88.92	+63
4521.23	.....	.....	21.32	+29	.....	.....	.....	.....	.....	.....	.....	.....
4524.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.09	+43
4536.55	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4537.06	.....	.....	37.23	+42	.....	.....	.....	.....	.....	.....	.....	.....
4538.57	38.97	+40	38.74	+17	.....	.....	.....	.....	36.98	+17	39.24	+67
4547.19	47.76	+57	.....	.....	.....	.....	47.73	+52	47.61	+42	47.79	+59
4573.09	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	78.64	+55
4579.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	79.75	+49
4580.77	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	81.27	+50
4583.49	83.64	+15	.....	.....	.....	.....	.....	.....	.....	.....	83.94	+45
4585.07	85.38	+31	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4614.73	.....	.....	15.00	+27	.....	.....	.....	.....	.....	.....	.....	.....
4617.78	.....	.....	.....	.....	18.07	+29	18.07	+29	.....	.....	18.21	+43
4621.09	21.32	+23	21.41	+32	21.66	+57	21.49	+40	.....	.....	.....	.....
4638.57	38.72	+15	39.04	+47	39.11	+54	39.13	+56	.....	.....	38.88	+31
4641.47	41.71	+24	.....	.....	.....	.....	42.08	+61	.....	.....	.....	.....
4644.82	65.38	+56	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4738.39	.....	.....	38.63	+24	.....	.....	38.93	+54	38.72	+33	.....	.....
4829.86	.....	.....	30.30	+44	.....	.....	.....	.....	.....	.....	30.59	+73
5012.93	.....	.....	.....	.....	.....	.....	13.05	+12	.....	.....	.....	.....
5017.26	17.87	+61	17.39	+13	17.59	+33	17.56	+30	17.58	+32	.....	.....
5068.55	.....	.....	68.50	-5	.....	.....	68.91	+36	.....	.....	69.13	+58
5074.05	75.34	+69	74.74	+9	.....	.....	75.03	+38	74.78	+13	75.00	+35
5079.96	.....	.....	.....	.....	.....	.....	80.45	+49	.....	.....	.....	.....
5111.89	.....	.....	.....	.....	.....	.....	.....	.....	12.07	+18	.....	.....
5116.56	.....	.....	.....	.....	17.11	+55	.....	.....	.....	.....	.....	.....
5122.55	23.19	+64	22.60	+5	.....	.....	.....	.....	.....	.....	32.25	+50
5131.75	.....	.....	31.96	+20	.....	.....	.....	.....	.....	.....	50.92	+52
5150.40	.....	.....	.....	.....	.....	.....	.....	.....	50.65	+15	.....	.....
5164.02	64.45	+43	.....	.....	64.83	+81	.....	.....	.....	.....	.....	.....
5186.45	86.93	+48	86.77	+32	86.99	+54	87.21	+76	.....	.....	.....	.....
5692.68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	93.19	+51
5710.18	.....	.....	10.62	+44	.....	.....	.....	.....	.....	.....	.....	.....
Mean Δ, t.m.	+41		+26		+56		+45		+24		+52	
Mean Δ, km.	+26		+16		+34		+27		+14		+33	
V of 132 Schj.	-28		-23		-28		-28		-28		-28	
Velocity in km.	-2		-12		+6		-1		-14		+5	

## RADIAL VELOCITY OF 280 SCHJELLERUP

From bright lines compared with 19 Piscium

The character of the spectrum of 280 *Schjellerup* differs so much from that of 132 *Schjellerup* that direct comparison of the bright lines was unsatisfactory; therefore they were compared with the lines in 19 *Piscium*, a star more nearly like 280 *Schjellerup* in development.

19 Piscium	280 Schjellerup	ΔΔ	19 Piscium	280 Schjellerup	ΔΔ
t.m.	t.m.	t.m.	t.m.	t.m.	t.m.
4617.77	17.36	-41	5531.92	31.20	-72
4631.12	30.50	-53	5571.81	71.57	-24
4638.72	37.65	-1.07	5580.71	81.09	-38
4690.88	69.09	-79	5724.08	23.96	-12
5453.81	52.18	-1.63	5756.98	57.57	-59
5459.10	58.61	-49	.....	.....	.....

Mean - .46 t.m.  
= -25 km.

## MEAN RADIAL VELOCITIES

The final adopted velocities are the means of the direct determinations by dark lines and the comparison of the bright lines with those of 132 *Schjellerup*. The close agreement in certain stars of the results obtained with the dark and bright lines is of course purely fortuitous, as the values in either case may be many kilometers in error.

STAR	DARK LINES		BRIGHT LINES COM- PARED WITH 132 <i>Schj.</i>		MEAN
	V	No. Lines	V	No. Lines	V
132 <i>Schjellerup</i> .....	-18	..	....	..	-28
280 <i>Schjellerup</i> .....	-25	17	-25	16	-25
19 <i>Piscium</i> .....	-2	24	-2	13	-2
318 <i>Birmingham</i> .....	-8	15	-12	14	-10
74 <i>Schjellerup</i> .....	+3	13	+6	9	+5
78 <i>Schjellerup</i> .....	-1	14	-1	13	-1
115 <i>Schjellerup</i> .....	-11	9	-14	11	-13
152 <i>Schjellerup</i> .....	-4	13	+6	16	+1

For a check on these results see the table on p. 118.

## TABLE OF CORRECTIONS FOR RADIAL VELOCITY

The corrections to be applied to the measured wave-lengths of the star lines (after reduction to the Sun) to eliminate the displacements due to radial velocity are given in the following table. The displacements are given in hundredths of an Ångström unit.

V in km.								V in km.							
λ	1	2	5	10	13	25	28	λ	1	2	5	10	13	25	28
4200	1	3	7	14	18	35	39	5100	2	3	9	17	22	43	48
4300	1	3	7	14	19	36	40	5200	2	3	9	17	23	43	49
4400	1	3	7	15	19	37	41	5300	2	4	9	18	23	44	50
4500	2	3	8	15	20	38	42	5400	2	4	10	18	23	45	50
4600	2	3	8	15	20	38	43	5500	2	4	10	18	24	46	51
4700	2	3	8	16	20	39	44	5600	2	4	10	19	24	47	52
4800	2	3	8	16	21	40	45	5700	2	4	10	19	25	48	53
4900	2	3	8	16	21	41	46	5800	2	4	10	19	25	48	54
5000	2	3	8	17	22	42	47								

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY

The following table contains the mean wave-lengths of the lines measured in each star, with the correction for radial velocity, and the final mean of all the wave-lengths of the same line measured in each star. The stars are arranged in the assumed order of development.

No.	288 <i>Schedlerup</i>			19 <i>Piscum</i>			318 <i>Birmingham</i>			74 <i>Schedlerup</i>		
	Inten- sity	Character	Wave-Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length
			t.m.			t.m.			t.m.			t.m.
1	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
1a	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
2	..	.....	.....	10	w D	84.08	...	.....	.....	...	.....	.....
3	..	.....	.....	2-3	n D	90.33	...	nn D	90.03	...	.....	.....
4	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
5	..	.....	.....	6-7	w D	94.83	...	wn D	95.17	...	wn D	95.06
6	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
7	..	.....	.....	1	D	97.65	...	.....	.....	...	.....	.....
8	..	.....	.....	2	D	00.87	...	wn D	01.02	...	wn D	00.7
9	..	.....	.....	3	B	02.47	3-4	n B	02.47	2-3	n B	02.61
10	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
11	..	.....	.....	7	w D	04.98	2-3	wn D	05.15	...	nn D	05.1
12	..	.....	.....	3	D?	08.51	...	.....	.....	...	wn D	08.61
13	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
14	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
15	..	.....	.....	1	D?	12.29	...	.....	.....	...	.....	.....
16	..	.....	.....	...	.....	.....	...	B? \	09.8	...	.....	.....
17	..	.....	.....	3	n D	15.17	2-3	n D	14.2	...	.....	.....
18	..	.....	.....	...	.....	.....	...	.....	15.11	...	nn D	15.3
19	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
20	..	.....	.....	2-3	wn D	20.60	...	.....	.....	...	.....	.....
21	..	.....	.....	...	B?	.....	...	.....	.....	...	.....	.....
22	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
23	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
24	..	.....	.....	...	.....	.....	1-2	n D	25.86	...	.....	.....
25	..	.....	.....	1	B	26.81	...	.....	.....	...	.....	.....
26	..	.....	.....	2	D	27.49	2-3	n D	27.96	3	nn D	27.8
27	..	nn D	4429.51	2-3	n D	30.18	1-2	n D	30.27	...	nn D	30.42
28	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
29	..	.....	.....	...	.....	.....	1	n D	33.96	...	.....	.....
30	..	.....	.....	...	.....	.....	...	B \	31.0	...	.....	.....
31	3	nn D	4435.22	5	w D	35.52	5	wn D	33.60	...	wn D	35.72
32	..	.....	.....	...	.....	.....	...	.....	35.49	...	.....	.....
33	..	.....	.....	1	D	38.13	1-2	n D	38.23	...	.....	.....
34	..	.....	.....	2	B??	38.89	5-6	n B	39.10	...	.....	.....
35	..	B? }	37.0	...	.....	.....	...	.....	.....	...	.....	.....
36	..	.....	39.9	2-3	n D	44.45	1-2	D	44.45	...	.....	.....
37	..	.....	.....	...	B??	.....	...	.....	.....	...	.....	.....
38	..	.....	.....	...	.....	.....	...	B }	45.0	...	.....	.....
39	..	.....	.....	...	.....	.....	...	.....	46.8	...	.....	.....
40	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
41	..	.....	.....	1-2	n D??	47.14	2	n D	47.47	...	.....	.....
42	..	.....	.....	2-3	n B?	48.68	4	n B	48.61	5	n B	48.88
43	..	.....	.....	5	n D	49.96	...	wn D	50.04	...	nn D	50.35
44	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
45	..	.....	.....	2-3	n D	55.23	1	n D	55.35	...	nn D	55.8
46	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
47	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
48	..	.....	.....	...	.....	.....	...	.....	.....	...	.....	.....
49	..	.....	.....	...	.....	.....	...	.....	.....	...	nn D	60.01
50	..	.....	.....	3	n D	62.17	3	n D	62.07	...	nn D	62.48
51	..	nn B??	4463.76	3-4	w B	64.04	6	n B	63.91	...	w B	64.0

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	
		t.m.			t.m.			t.m.			t.m.	t.m.
...	...	...	...	head	71.80	...	...	...	...	...	...	4371.8
...	...	...	...	head	80.63	...	...	...	...	...	...	4380.6
...	...	...	1	n D	85.20	...	...	...	...	...	...	4384.6
2	n D	89.82	1-2	n D	89.77	...	...	...	...	...	...	4390.0
...	...	...	2	n D	91.95	...	...	...	...	...	...	4391.9
8	wn D	95.10	...	n D	95.1	...	...	...	...	...	...	4395.0
...	...	...	...	{ con.	95.8	...	...	...	...	...	...	439
...	...	...	...	{ spec.	97.9	...	...	...	...	...	...	4397.9
...	...	...	1-2	n D	98.24	...	...	...	...	...	...	4401.0
8	wn D	01.14	1-2	wn D	00.89	...	...	...	...	...	...	4402.6
...	n B?	02.68	2	n B	02.47	...	...	...	2-3	B??	02.70	4403.3
...	...	...	4	D?	03.30	...	...	...	...	...	...	4405.1
...	nn D	05.21	1 2	wn D	05.24	nn D?	04.92	3	n D?	04.91	...	4408.5
3	nn D	08.75	1	wn D	08.52	1	n D?	07.90	...	...	...	440
...	...	...	...	...	...	...	...	...	...	D {	03.3	440.9
...	...	...	...	n D??	11.20	...	...	...	1	n D	10.58	4410.9
...	...	...	1-5	nn D?	12.23	...	...	...	1-2	n D	12.45	4412.3
...	...	...	...	{ con.	12.7	...	...	...	...	...	...	4418.5
...	...	...	...	{ spec.	14.7	...	...	...	...	...	...	4415.2
3	nn D	15.18	1-3	n D	15.28	...	...	...	3-4	n D	15.45	4416.7
...	...	...	2	D?	16.71	...	...	...	...	...	...	441
...	...	...	...	{ con.	18.0	...	...	...	...	...	...	4420.6
...	...	...	...	{ spec.	20.3	...	...	...	...	...	...	4421.0
...	nn D	20.5	2	n D	20.60	...	...	...	1	B?	20.81	4421.7
...	...	...	2 3	D	21.70	...	...	...	...	...	...	4423.9
...	...	...	3	n B?	23.99	...	...	...	2	B??	23.88	4425.9
...	nn D	26.25	1-6	nn D?	25.86	...	...	...	2	n D	25.80	4426.8
...	...	...	6	B??	16.69	...	...	...	...	...	...	4427.7
1	nn D	27.63	1 6	n D	27.72	...	...	...	2	n D	27.74	4430.2
1	nn D	30.37	1-2	n D	30.28	...	...	...	2-3	n D	30.54	442
...	...	...	...	D {	29.6	...	...	...	...	...	...	4433.9
...	...	...	...	n D?	30.9	...	...	...	...	...	...	4431.0
...	...	...	1	n D?	33.92	...	...	...	...	...	...	4434.3
...	...	...	...	{ con.	30.9	...	...	...	...	...	...	4435.6
6-7	wn D	35.92	3	{ spec.	35.0	4-5	wn D	35.47	6	wn D	35.97	443
...	...	...	...	wn D	35.60	...	...	...	...	...	...	4438.2
...	...	...	...	D {	35.0	...	...	...	...	...	...	4439.0
...	...	...	...	36.3	...	...	...	...	1-2	n D	38.25	443
1	nn D	38.14	1-7	n D	38.14	...	...	...	...	...	...	4444.5
2-3	n B	39.44	4	n B	38.86	3	n B?	38.71	...	B??	...	4445.2
...	...	...	...	...	...	...	...	...	...	...	...	444
2	n D	44.58	1-6	n D	44.51	...	...	...	1	n D	44.64	4445.7
...	...	...	5	B?	45.16	...	...	...	2	B	45.32	4446.3
...	...	...	...	...	...	...	...	...	...	...	...	4447.5
...	...	...	2	D??	45.68	...	...	...	2	D	45.79	4448.7
...	...	...	3	n B?	46.14	...	...	...	1	n B??	46.37	4450.1
1	nn D	47.06	2	n D??	47.44	...	...	...	2	n D?	47.57	4454.2
2 3	n B	48.88	8	n B	48.65	...	...	...	...	...	...	4455.4
3	n D	50.32	2-3	n D??	50.04	2-3	wn D	50.02	...	wn D??	50.3	4456.7
...	...	...	5	B	54.23	...	...	...	...	...	...	4458.1
1-2	n D	55.52	1-3	D?	55.33	...	...	...	1	n D	55.38	4458.8
...	...	...	0-1	D?	56.76	...	...	...	...	...	...	445
...	...	...	...	...	...	...	...	...	1	n D	58.08	4462.2
...	...	...	4	n B??	58.81	...	...	...	1	B?	58.72	4464.0
...	...	...	...	{ D?	59.3	...	...	...	...	...	...	4462.2
...	...	...	...	60.1	...	...	...	...	...	...	...	4464.0
2	n D	62.24	8	w D	62.10	...	n D?	62.2	4-5	n D	62.05	4464.0
3	n B	63.84	2-8	B	64.08	...	...	...	2-7	n B	64.09	4464.0

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	28 S. <i>Alcyon</i>			19 <i>Piscum</i>			318 <i>Berningham</i>			71 <i>Schjellerup</i>		
	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length
			t.m.			t.m.			t.m.			t.m.
52											B	63.1
53	1	wn D	4465.96	1	D?	65.29	1	n D	65.43			64.80
54												
55				1-2	D	68.95						
56	1	n D	4471.64	1	D??	72.25	1	nn D	71.72			
57												
58					B?							
59								B	72.4			
60								B	72.4			
61									74.5			
62				1-2	n D	75.52	1	n D	76.18	1	nn D	75.4
63					B?			B??		max	B	79.0
64				1-2	n D??	80.00	1	nn D	80.42	1	nn D?	80.22
65	1	nn D	4481.74	2-3	D	82.19	2-3	n D	82.41	1	nn D	82.34
66				2-3	n B	83.62	2	n B	83.64			
67												
68				2	B?	86.03	1-2	n B?	86.27			
69				1-2	D	87.57	2	nn D	87.42	1-2	nn D	87.61
70				3	B?	88.61						
71	1	n D	4489.35	2-3	D	89.75	3	n D	89.80	1	D	90.05
72												
73		wn D	4496.73	4-5	D	97.02		wn D	96.97	2	n D	97.21
74					B??	98.0						
75		nn D	4501.22	4	D	01.1	2-3	nn D	01.78	1-2	nn D	01.97
76						01.78			01.87			
76a		head			head	02.3		head	02.6		head	02.5
77								B	02.5		B	02.5
78	2	n D	4506.38	6	D	06.77	2-3	n D	06.3	2-3	n D	06.3
79					B??		6	n B?	07.08			07.04
80				1	D?	09.77	1	n D	08.64			
81					B??		4	B??	09.56	1	nn D	09.91
82									10.8			
83	3?	nn D	4512.83		wn D	12.76	2	nn D			nn D	12.3
83a					head	14.3			12.64			
84				1	D?	16.17						
85				2	n B	17.05	max	B				
86	1-2	n D	4518.15	3-4	D	18.27	3	n D	17.71	1-2	n D	18.38
87				1	D??	20.54			18.31			
88	1-2	nn B	4521.15	3-4	B	21.66	3	wn B	21.67	8	wn B	21.91
89												
90	1	n D	4522.91	1	D	23.00	4-5	D	23.06	1-2	nn D	23.20
91					B??							
92												
93				5	n D	27.16				0	nn D	27.40
94							1	nn D	28.65			
95				2-3	D	31.35	1	nn D	31.43	1	nn D	30.96
95a					head	31.9						
96												
97		w D	4535.30	6	w D	35.84		nn D	35.84		nn D	35.90
98		D	4530.7					D	36.6			
99		w D	4537.98	3	B	37.32	3	wn B	37.38			
100				2-3	B	39.00	2	n B?	38.89			
101								B	36.5		B	36.6
102	1	n D	4539.80	2	D	40.42	1	n D	39.7			39.9
103				1	D??	42.75			40.51	1-2	nn D	40.57
104												
105				2	B	44.10						

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	
...		t.m.	...		t.m.	...		t.m.	...		t.m.	t.m.
...	B	{ 62.9	...	B	{ 63.0	...		...	...	B	{ 64.6	4463.0
...		{ 65.1	...		{ 64.8	...		...	...		{ 64.6	4464.9
1	n D	65.37	1	n D??	65.76	...		...	...	n D??	64.88	4465.4
...			2	D	66.90	...		...	...			4466.9
1	n D	68.68	1	n D	69.02	...		...	1	n D	68.48	4468.8
2	nn D	71.58	2	n D??	71.72	1	D	70.85	1	n D??	71.81	4471.7
...		{ 65.0	...		...	...		...	...	con.	{ 64.6	4464.7
...	D	{ 72.0	...		...	...		...	...	spec.	{ 72.6	4472.0
...			2	B??	72.32	...		...	1	n B??	72.57	4472.4
...			4-5	B	73.55	...		...	3	n B	73.56	4473.6
...			...		{ 73.0	...		...	...			4472.7
...			...		{ 75.0	...		...	...			4474.7
...			1	n D	75.31	...		...	...			4475.3
1	n D	75.33	1	D	75.82	...		...	...			4475.6
...			3	B	79.08	1	B?	78.58	...	wn B??	78.78	4478.8
1	nn D?	80.21	2-3	n D??	80.13	...		...	2	n D??	79.96	4480.2
2	n D	82.23	2-5	D	82.50	...		...	2	n D	82.43	4482.3
...			1	B??	83.46	2	nn B??	84.13	...			4483.7
...			con.	{ 83.0	...	...		...	...		{ 82.9	{ 448
...			spec.	{ 86.0	...	...		...	...	B?	{ 87.8	
...			5	n B??	86.15	2	n B??	85.87	...			4486.1
1	nn D	87.62	1-3	n D	87.73	...		...	1	nn D?	87.28	4487.5
...			1-5	B??	88.70	...		...	1	B?	88.84	4488.7
2-3	n D	89.86	2-3	n D	89.77	...		...	3	nn D	89.61	4489.7
...			con.	{ 90.4	...	...		...	...	B?	{ 90.4	4490.4
...			spec.	{ 96.2	...	...		...	...			4496.
3-4	n D	96.97	6-8	w D	96.99	1-2	n D	97.04	...			4497.0
...			con.	{ 98.0	...	...		...	...			4498.0
...			spec.	{ 01.3	...	...		...	...			4501.2
1	nn D	01.87	1-8	w D	01.92	1	nn D	00.91	1	n D	02.15	4501.7
...			3	B??	03.14	1	n B?	03.91	2-3	nn B??	03.79	4503.6
...	head	02.7	...	head	02.71	...		...	...			4502.8
...	B	{ 02.7	...	B	{ 02.4	...		...	...			4502.5
...		{ 06.2	...		{ 06.0	...		...	...			4506.2
3-4	wn D	07.09	2	wn D	07.12	2	n D	06.74	2	nn D	07.24	4506.9
1	wn B	08.71	max	B??	08.65	3	n B	08.21	...	B??		4508.6
4	nn D	09.84	1-3	n D??	09.89	...		...	3	n D??	09.96	4509.8
...			3	n B??	10.66	...		...	...			4510.7
...	B	{ 08.30	...	B	{ 08.3	...		...	...			4508.3
...		{ 11.60	...		{ 09.5	...		...	...			
...	wn D	13.08	2	wn D	12.83	1-2	nn D	13.05	1	nn D	12.81	4512.8
...			head	15.15	...	...		...	...			4514.7
...			1	n D	16.34	...		...	1	nn D?	16.02	4516.2
1-2	n B	17.13	4	n B??	17.31	...		...	1	B??	17.20	4517.3
2-3	n D	18.53	1-3	n D	18.35	1-2	n D	18.21	1 2	wn D?	18.23	4518.3
...			1	n D??	20.71	...		...	1	nn D??	20.16	4520.5
4	B	21.89	3	B??	21.75	...		...	...	B??		4521.7
...			...	B	{ 20.9	...		...	...			{ 452
...			...		{ 22.4	...		...	...			
4	n D	23.23	4-6	w D	23.17	2-3	n D	23.08	5	n D	23.21	4523.1
3-4	n B	25.01	3	B??	24.68	3	n B??	24.59	2-5	B?	24.63	4524.7
...		{ 24.1	...	B	{ 23.9	...		...	...			4524.0
...		{ 26.0	...		{ 27.3	...		...	...			4527.
...	wn D	27.56	1	n D?	27.2	...	n D?	27.48	...			4527.4
...			3	D	28.69	...		...	...			4528.7
1	n D?	31.32	1	n D	31.29	...		...	...			4531.3
...			head	32.73	...	...		...	...			4532.3
...			3	n D	33.44	...		...	...			4533.4
2-3	n D	35.70	6-8	wn D?	36.04	...	n D	35.56	1-2	n D	36.21	4535.7
...		{ 31.1	...		...	...		...	...			4530.9
...	D	{ 36.7	...		...	...		...	...			4536.3
2	n B?	37.32	2-3	n B?	37.45	...	n B?	37.08	2-4	n B	37.68	4537.5
2-3	B	39.18	3-6	n B??	39.00	1	B	38.66	4-5	B	39.16	4539.0
...			...	B	{ 36.6	...		...	...	B	{ 37.2	4536.7
...			...		{ 40.0	...		...	...		{ 40.2	4540.0
3	n D	40.66	3	wn D?	40.46	...		...	...	n D	40.44	4540.4
...			2	n D??	42.51	...		...	2-3	wn D??	43.06	4542.8
1	B	44.25	max B??	44.40	...	...		...	1	n B?	44.10	4544.2
...			n D	44.92	...	...		...	...			4544.9

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	20 S. A. Star			19 Piscium			318 Birmingham			74 Schjellerup		
	Inten- sity	Character	Wave-Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length
			t.m.			t.m.			t.m.			t.m.
106			.....	3	B	47.79	4	n B?	47.71	max	B	47.56
107			.....			.....			.....		B	46.8
108			.....	5	wn D	49.25		wn D	49.37			48.5
109			.....			.....			.....			.....
110			.....			.....			.....			.....
111			.....			.....			.....			.....
112	9	w D	4553.58	10	w D	53.54		wn D	53.58		wn D	54.07
113			.....		D	51.8		D	52.3			.....
113a			.....		head	54.7		head	55.3			.....
114			.....			.....			.....	max	B	58.40
115		B	4555.5		B	55.3		B	55.3		B	55.40
116		nn D?	4559.3	3	n D	59.3	5	nn D	59.4		nn D	59.90
117			.....	3	n B	60.39			60.42			60.48
118	1	D	4562.93	2-3	D??	61.91	3	D	63.35		nn D	63.47
119			.....		B??	.....			.....			.....
120	0.1	D	4565.22	1-2	D??	65.73	1-2	D	65.71	1	n D	65.74
121			.....			.....			.....			.....
122			.....			.....			.....			.....
123		B	4565.90		B	66.2		B	66.2			.....
124			4569.50			70.0			70.5			.....
125		nn D	4571.57	9	w D??	71.66		wn D	71.79		nn D	71.50
126			.....	3	n D	75.27		nn D?	75.10			.....
127			.....	3.4	n D	77.57	1	nn D	77.47		n D	77.60
128			.....			.....		D	70.9			.....
129			.....		head	78.1		head	77.0			.....
129a			.....			.....			.....			.....
130			.....			.....			.....			.....
131			.....			.....			.....			.....
132			.....	1	D	80.42	1	nn D	80.52			.....
133			.....			.....			.....			.....
134			.....	1	D??	81.93	1	nn D	82.57			.....
135	5.6	wn B	4583.59	2	n B	83.67			.....			.....
136			.....	1-2	D	84.57	1	n D	84.82			.....
137			.....	1	B?	85.41			.....			.....
138	2	n D	4586.38	2	n D	86.37	1	nn D?	86.10			.....
139			.....			.....			.....			.....
140			.....			.....			.....			.....
141			.....			.....			.....			.....
142			.....			.....			.....			.....
143			.....			.....			.....			.....
144			.....	1	D?	91.01	1-2	nn D	91.26			.....
145			.....			.....			.....			.....
146	1	n D	4591.19	2-3	n D	94.34	2	nn D	94.30		nn D	94.69
147	2	nn B?	4596.11	2	n B	95.80	5	n B	96.10	4	n B	96.15
148			.....			.....			.....			.....
149			.....	1	n D??	97.52	2	n D	97.61			.....
150			.....			.....			.....			.....
151	1	n B?	4599.58	1.2	n D	00.84	3	n D	00.61	1	n D	00.87
152			.....			.....			.....			.....
153			.....			.....			.....			.....
154			.....			.....			.....			.....
155			.....			.....			.....			.....
156	7.8	D	4606.26	9	w D	06.87	10	w D	06.86	8	w D	06.88
157		head	4607.5		head	07.9	head		08.3			.....
158			.....			.....		D	05.7			.....
159	3	n B	4608.47	2.3	n B	08.71	2	n B?	08.3	5	n B??	08.90
160		B	4607.5			.....		B	08.3			.....
161			4615.0			.....			13.1			.....
162			.....	1	n D??	10.07	1	nn D?	10.57	1	n D	10.56

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	
2-3	n B	t.m. 47.75	4 6	B	t.m. 47.63	1	B	t.m. 47.81	4	n B	t.m. 47.73	4547.7
...	...	...	...	...	...	...	...	...	...	...	...	{ 454
3	wn D	49.25	1	nn D?	49.47	...	...	...	5-6	n D	49.27	4549.3
...	...	...	...	D	{ 48.8	...	...	...	...	...	...	{ 454
...	...	...	...	...	{ 50.1	...	...	...	...	...	...	{ 455
...	...	...	...	B	{ 50.0	...	...	...	...	...	...	{ 455
...	...	...	...	nn D?	52.3	...	...	...	...	...	...	{ 455
7	wn D	53.79	4	w D	52.85	4	n D	54.00	...	wn D	52.65	4552.8
...	...	...	...	D	54.21	...	...	...	...	...	...	4553.8
...	D	{ 55.3	...	D	{ 52.1	...	...	...	...	...	...	4552.0
...	...	...	...	head	55.4	...	...	...	...	...	...	4555.1
...	...	...	...	nn B??	54.68	...	...	...	1	n B??	58.85	4554.9
...	B	{ 55.3	3-4	nn B??	58.88	...	...	...	...	...	...	4558.7
...	...	{ 59.7	...	B	{ 55.3	...	...	...	...	...	...	4555.3
4	n D	60.47	...	nn D??	59.6	...	...	...	...	...	...	4559.5
3-4	n B	62.10	1-3	B??	60.23	nn D?	60.35	2	n D	60.21	62.27	4560.3
3	n D	63.51	2	n D	62.25	2	n D	63.56	1	n B??	62.27	4562.1
2	n B??	64.71	2	n B??	63.45	...	...	...	3	n B	64.68	4563.5
1	nn D	65.61	1	wn D??	64.57	5	n D	65.85	...	D?	...	4564.7
...	...	...	...	...	65.95	...	...	...	2-3	wn B	67.72	4565.8
...	...	...	2-3	B??	69.46	...	...	...	...	...	...	4567.7
...	B	{ 66.3	...	B	{ 64.0	...	B	{ 66.8	...	...	...	4569.5
...	...	{ 70.3	...	...	{ 70.0	...	...	{ 69.4	...	...	...	4566.3
...	n D	72.55	...	...	...	...	...	...	2	B	70.31	4569.8
...	...	...	...	...	...	...	...	...	...	...	...	4570.3
...	...	...	2	B?	73.71	...	...	...	...	...	...	4571.8
...	...	...	1	n D?	75.78	...	...	...	...	...	...	4573.7
1	n D?	77.26	1	n D?	77.61	...	...	...	2	D	77.67	4575.4
...	D	{ 70.3	...	...	...	...	D	{ 73.8	...	D	{ 70.9	4577.5
...	head	78.1	...	head	78.05	...	head	{ 77.2	...	...	{ 78.4	4574.2
...	...	...	4	B	78.52	...	...	...	...	...	...	4577.7
2	nn B?	79.37	...	...	...	...	...	...	1-2	B?	78.56	4577.6
...	...	...	...	B	79.69	...	...	...	2	n B	78.96	4578.5
1-2	nn D	80.47	1-4	n D	80.38	...	...	...	1-2	B	79.67	4579.2
1	n B	81.68	4	B	81.20	...	...	...	1-3	n D	80.50	4579.7
1-2	nn D	82.51	1	n D??	82.85	...	...	...	1-2	nn B?	81.19	4580.5
2-3	n B	83.93	5	B	83.92	...	...	...	...	n D	82.94	4581.4
...	...	...	3	D	84.72	...	...	...	1	B?	83.86	4582.6
1	B	85.62	5	D	85.50	...	...	...	...	n D?	84.72	4583.8
1	n D	86.76	3	D	86.28	...	...	...	2	D	86.37	4584.7
...	...	...	2	B	86.89	...	...	...	...	...	...	4585.5
...	...	...	2	D?	87.43	...	...	...	...	...	...	4586.4
...	...	...	...	B??	...	...	...	...	...	...	...	4586.9
max	B	89.85	3-4	B?	90.39	...	...	...	2	B	89.07	4587.4
1	n D	91.39	4	n D	91.10	1	n D?	91.14	2	B?	90.54	4589.1
...	...	...	...	...	...	...	...	...	2	D	91.25	4590.3
...	...	...	...	...	...	...	...	...	...	...	...	4591.2
...	...	...	...	...	...	...	...	...	...	B	{ 89.9	{ 459
...	...	...	3	D	94.10	...	...	...	...	...	{ 93.2	{ 459
4	n B	96.04	4-6	nn B?	96.08	...	...	...	1-5	n D	93.93	4594.3
...	...	...	...	...	...	...	...	...	max	B	{ 95.42	4596.0
...	...	...	...	...	...	...	...	...	...	B	{ 94.6	{ 459
1	nn D?	97.32	1	wn D?	97.33	0-1	n D	97.34	1-2	nn D??	97.37	4597.4
1	n B?	99.33	3-4	n B?	99.53	...	...	...	max	B??	99.22	4598.5
2	n B	01.00	4	D	01.00	1	nn D	00.68	...	n D	00.89	4600.8
...	...	...	4	B	02.01	...	...	...	1	n B??	02.27	4602.1
...	...	...	2	D	02.95	...	...	...	...	nn D?	02.83	4602.9
...	...	...	1	n D	06.23	...	...	...	...	...	...	4606.2
3 4	n D	07.20	...	w D	06.83	2-3	n D	06.24	...	wn D	06.37	4606.7
...	...	...	...	n D	07.50	...	...	...	...	...	...	4607.5
...	head	08.2	4	head	08.01	...	head	08.5	...	...	...	4608.1
...	D	{ 02.9	...	D	{ 03.0	...	n D	{ 05.4	...	...	...	4608.6
...	...	{ 08.3	...	...	{ 08.5	...	...	{ 08.5	...	...	...	4608.4
2	n B?	08.17	...	B??	08.2	...	...	...	...	n D?	08.92	4608.9
...	B	{ 08.4	...	B	{ 08.2	...	...	...	...	...	...	4608.1
...	...	{ 13.3	...	...	{ 08.9	...	...	...	...	...	...	4610.3
1	n D	10.22	2	D	10.17	...	...	...	...	...	...	4610.3

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY *Continued*

No.	258 S. 100° 10' 10"			B $\gamma$ Spectrum			318 Birmingham			74 Schjellerup		
	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length
			t.m.			t.m.			t.m.			t.m.
163					D??							
164				1-2	B??	12.32	1	n B??	12.39			
165				1-2	n D	13.80	2 3	n D	13.73	2	n D	13.77
166				3	B	14.95	5-6	n B	15.15	6	n B	15.03
167	1	n D	4616.06	2-3	D	16.29	3 4	n D	16.46	3	n D	16.31
168												
169	4	B	4617.74	6	B	17.80	7 8	n B	18.03	9	w B	17.99
170	1	n D	4619.29	5	D?	19.68	6	D	19.86	3	n D	19.70
171				4	B	21.35	5	n B	21.56	5	n B	21.58
172				1-2	n D??	22.81	2-3	nn D	23.05	1-2	nn D	23.09
173												
174												
175												
176											B	23.6
177					D??							27.9
178				5	wn D	29.26	8	n D	29.54	6 8	nn D	29.12
179												
180	4	n B	4630.97	4	B	31.15	2	n B?	31.34	9	n B	31.18
181												
182				1	D	34.61				1	nn D	34.6
183				2	D	37.46	1	nn D	37.41			
184	2	n B?	4638.03	3	B	38.75	3-4	n B	39.19	6	n B	39.03
185	3	n D	4639.86	5 6	D	40.29	6	D	40.46	5	D	40.76
186												
187	1-2	n B	4642.10	3 4	B	41.72	4	wn B	42.16	8-9	w B	42.31
188					B??							
189		B	4640.6					B	41.3		B	41.1
190	4	D	4644.1						44.1			43.2
191			4646.05		wn D	45.70					wn D	46.30
192				2-3	n B??	52.80				1	nn B??	53.05
193				1	D?	54.04						
194	2-3	nn D	4655.25	1	D	56.6					wn D	56.30
195		n B	4660.48		w B	60.91						
196		B	4657.5									
197	1	D?	4662.2									
198	1	n B?	4663.92	1-2	n D	64.14						
199	1	n B	4665.21	2	n B	65.41				1-2	n B	65.24
200	4	n D	4668.15	3	wn D	68.08						
201	2	n D	4674.79	4	D	75.13						
202		wn D	4682.16	1	D?	82.29						
203				1	n D??	88.43						
204				1	n D?	91.12						
205				3 4	n D	96.56						
206					head	97.2						
207					D??							
208												
209	5	n D	4714.49	6	w D	14.61					wn D	15.00
210												
211					head	14.8					D	13.0
212					B??							16.4
213					B??							16.4
214										1-2	n B??	20.38
215											B?	21.3
216				1 2	n D	22.69				1	n D	22.85
217												
218		nn D	4728.61							1	nn D	28.5
219												
220				10	w D	36.26	10	w D	36.3	10	w D	36.24
221		D	4732.5					D	37.3		D	37.3
			4737.6						37.9			37.6
		head	4737.6		head	37.61		head	37.9		head	37.6

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY — *Continued*

78 Schjellerup			132 Schjellerup			115 Schjellerup			132 Schjellerup			MEAN WAVE-LENGTH
Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	
		t.m.			t.m.			t.m.			t.m.	
...	...	...	2	D??	11.32	...	...	...	2	D??	11.42	4611.4
1	n B?	12.31	2	n B??	12.49	...	...	...	2	B??	12.23	4612.3
2	n D	13.98	3-4	nn D	13.89	1-2	n D	13.91	1-3	n D	13.93	4613.9
6	B	15.21	4-9	n B	15.23	...	...	...	2	B	15.14	4615.1
3	D	16.56	2-5	n D	16.36	3-8	w D	16.42	...	...	...	4616.4
...	...	...	1-2	B??	17.16	...	...	...	...	B??	...	4617.2
6-7	B	18.09	6-8	B	18.23	3	n B	17.74	4-8	B	18.15	4618.0
6	D	19.85	2	n D	19.56	1-2	n D	19.42	3-4	D	19.40	4619.6
5	B	21.51	2-6	n B??	21.51	...	...	...	...	B??	...	4621.5
2-3	n D	22.99	2	n D??	23.26	...	...	...	1-2	n D??	22.47	4622.9
...	...	...	4-5	B	24.18	...	...	...	...	B??	...	4624.2
...	...	...	1-2	B	25.87	...	...	...	...	...	...	4625.9
...	n B?	27.9	2	B??	27.10	...	...	...	...	...	...	4627.1
...	...	...	...	...	...	...	...	...	...	...	...	462
...	...	...	1	n D??	28.66	...	...	...	...	...	...	4628.7
...	wn D	29.84	2	n D?	30.08	...	...	...	...	...	...	4629.6
...	...	...	1	n B?	30.98	...	...	...	...	...	...	4631.0
...	...	...	1	B??	31.60	...	...	...	...	...	...	4631.2
...	...	...	2	n B?	31.68	...	...	...	...	...	...	4631.7
...	...	...	1	D	34.14	...	...	...	...	...	...	4634.4
...	...	...	1	n D?	37.60	...	...	...	1	n D	38.07	4637.6
4-5	B	39.15	5-8	B	39.07	1-2	n B	38.78	1-4	n B	38.96	4638.9
5	D	40.60	4	D	40.59	1-2	nn D	40.37	5	wn D	40.55	4640.4
...	...	...	...	D	39.5	...	...	...	...	...	...	464
...	...	...	...	D	41.5	...	...	...	...	...	...	4642.1
3	n B	42.10	5-6	B	41.90	...	...	...	...	B??	...	4643.3
...	...	...	3	B	43.33	...	...	...	...	B??	...	4641.0
...	...	...	...	...	...	...	...	...	...	...	...	4643.9
...	n D	46.55	...	nn D?	46.86	...	...	...	...	...	...	4646.3
...	...	...	4	B??	53.08	...	...	...	...	...	...	4653.0
...	...	...	4	D	54.06	...	...	...	...	...	...	4654.0
1	n D	56.33	5	D	56.47	...	...	...	...	...	...	4656.4
...	...	...	...	n B??	60.42	...	...	...	...	B??	...	4660.6
...	...	...	...	...	...	...	...	...	...	...	...	465
...	...	...	1-3	n D?	64.21	...	...	...	...	...	...	4664.1
...	n B?	65.44	3-4	B	65.26	...	...	...	...	...	...	4665.3
1	n D	68.60	2-3	n D	67.87	nn D?	67.73	...	...	...	...	4668.1
...	...	...	...	D??	...	1 2	n D	74.92	...	...	...	4674.9
...	...	...	2	n D?	82.55	...	...	...	...	...	...	4682.3
...	...	...	nn D??	88.78	...	...	...	...	...	...	...	4688.6
...	...	...	...	D??	...	...	...	...	...	...	...	4691.1
...	...	...	...	D??	...	1	n D?	97.41	...	...	...	4697.0
...	...	...	...	...	...	...	...	...	...	...	...	4697.2
...	...	...	1	n D??	01.98	...	...	...	...	...	...	4702.0
...	...	...	1	n D	03.82	...	...	...	...	...	...	4703.8
...	...	...	1-3	B	09.75	...	...	...	...	...	...	4709.8
1	nn D	14.97	...	D??	...	...	...	...	...	...	...	4714.7
...	...	...	...	wn D??	15.55	...	...	...	...	...	...	4715.6
...	...	...	...	...	...	...	...	...	...	...	...	471
...	head	15.8	...	head	16.11	...	...	...	...	...	...	4716.1
max	B?	17.0	3	B	16.75	...	...	...	...	...	...	4716.8
...	...	...	2	B??	18.13	...	...	...	...	...	...	4718.1
...	...	...	2-3	B??	20.59	...	...	...	...	...	...	4720.5
...	con.	16.3	...	...	...	...	...	...	...	...	...	4716.4
...	spec.	21.3	...	...	...	...	...	...	...	...	...	4721.3
...	n D	22.69	2-3	n D	22.67	0-1	D	22.29	...	...	...	4722.6
...	...	...	...	con.	23.40	...	...	...	...	...	...	472
...	...	...	...	spec.	27.70	...	...	...	...	...	...	4729.2
...	...	...	...	D?	...	1	D	29.71	...	...	...	4731.6
...	...	...	2	n B	31.63	...	...	...	...	...	...	4732.5
...	...	...	1	n D??	32.51	...	...	...	...	...	...	4736.2
10	w D	36.43	10	w D	36.43	...	nn D	35.09	...	n D	36.6	4734.0
...	D	34.	...	D	37.8	...	...	...	...	...	...	4737.7
...	head	37.7	...	head	37.61	...	...	...	...	head	38.4	4737.7

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	2888442 Group			19 Piscium			318 Birmingham			74 Schjellerup		
	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length
222		n B	t.m. 4739.10	8	B	t.m. 38.62	5	n B	t.m. 38.79	10	n B	t.m. 38.69
223			.....	1	D??	39.85	1	n D	40.14	.....	.....	.....
224			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
225		B	{ 4737.6	.....	.....	.....	.....	B	{ 37.9	.....	B??	{ 39.6
226	10	n D	{ 4741.2	.....	.....	.....	.....	.....	{ 41.7	.....	.....	{ 42.1
227			4743.40	7-8	w D	43.94	10	w D	43.94	.....	wn D	43.84
227		D	{ 4741.2	.....	.....	.....	.....	D	{ 41.7	.....	D	{ 42.3
228		head	{ 4745.2	.....	.....	.....	.....	.....	{ 45.6	.....	.....	{ 45.6
229		n B	4745.37	.....	.....	.....	.....	head	45.69	.....	head	45.63
230			4746.99	6-7	B	46.52	4	w B	46.77	.....	.....	.....
231		B	{ 4745.2	.....	.....	.....	.....	B	{ 45.8	.....	B	{ 45.6
232			{ 4748.8	.....	.....	.....	.....	.....	{ 48.7	.....	.....	{ 48.6
232			.....	2	n D	49.62	.....	nn D	49.50	.....	nn D	49.2
233			.....	.....	D??	.....	.....	.....	.....	.....	.....	.....
234			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
235			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
236		wn B	4755.71	3	B	55.07	.....	.....	.....	.....	B	55.5
237			.....	1	D?	56.23	.....	.....	.....	.....	.....	.....
238			.....	2	B	56.94	.....	.....	.....	.....	.....	.....
239			.....	.....	.....	.....	.....	.....	.....	.....	B	{ 53.3
240	4-5	n D	4758.99	3	n D	58.41	4	n D	58.62	3 4	nn D	{ 57.7
241			.....	.....	B??	.....	.....	.....	.....	.....	.....	58.83
242			.....	.....	B??	.....	.....	.....	.....	.....	.....	.....
243			.....	.....	.....	.....	.....	.....	.....	.....	B	{ 60.1
244	1	n D?	4766.78	1	D	66.11	.....	nn D	66.47	.....	nn D?	{ 45.8
245			.....	.....	B??	.....	.....	.....	.....	.....	.....	66.33
246			.....	.....	B??	.....	.....	.....	.....	.....	.....	.....
247			.....	.....	.....	.....	.....	.....	.....	.....	B	{ 67.1
248			.....	.....	.....	.....	.....	.....	.....	.....	.....	{ 72.1
249			.....	1-2	n D	72.40	2-3	nn D	73.01	.....	nn D	73.15
250			.....	.....	B?	.....	.....	.....	.....	.....	.....	.....
251			.....	.....	.....	.....	.....	.....	.....	.....	B	{ 73.9
252		wn D	4783.1	2	n D	84.17	.....	.....	.....	.....	.....	{ 78.2
253			.....	.....	.....	.....	.....	.....	.....	1-2	nn D	84.43
254			.....	.....	.....	.....	.....	.....	.....	2	n D	89.26
255			.....	.....	.....	.....	.....	.....	.....	.....	B	{ 90.1
256			.....	.....	.....	.....	.....	.....	.....	.....	.....	{ 96.3
257			.....	.....	.....	.....	.....	.....	.....	8	n B?	02.44
258			.....	.....	.....	.....	2	n B?	10.54	.....	.....	.....
259			.....	.....	.....	.....	nn D	12.03	.....	.....	n D?	12.1
260			.....	.....	B?	.....	2	n B?	13.98	4	n B??	13.99
261	2	n D	4815.44	2	n D	15.80	3-4	n D	15.62	1	wn D	16.01
262		nn B?	4818.26	.....	.....	.....	.....	.....	.....	.....	B	18.0
263		nn D?	4822.75	1 2	n D?	23.91	3	n D	23.86	.....	wn D	22.9
264	2	n B?	4824.94	.....	B??	.....	.....	.....	.....	4-5	wn B??	23.51
265			.....	.....	.....	.....	.....	.....	.....	.....	.....	25.97
266	1	n D	4826.52	1-2	n D	27.81	3	n D	28.21	.....	wn D	28.23
267			.....	.....	.....	.....	3	n B	30.46	6	n B	30.36
268	2	n D	4832.49	1 2	n D	32.51	4 5	n D	32.56	5	n D	32.57
269			.....	1	n D	36.39	.....	.....	.....	.....	n D	36.2
270		nn D?	4839.78	1	n D	39.19	.....	.....	.....	.....	wn D	39.50
271			.....	1	D	43.49	1	D	43.62	1	nn D?	42.9
272			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
273			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
274			.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
275			.....	1	n D	55.31	.....	nn D	55.47	1	n D	55.64
276			.....	.....	B??	.....	1	n B?	57.68	3	n B	57.68
277			4857.42	1	n D	59.46	.....	.....	.....	.....	.....	.....
278	5	B	4861.38	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	
5	B	t.m. 38.95	5-7	B	t.m. 38.79	3-4	B	t.m. 38.92	...	B??	t.m. 39.50	t.m. 4738.9
...	...	...	...	n D??	39.84	1	n D	40.19	...	...	...	4740.0
...	...	...	4-5	n B	41.08	...	...	...	...	...	...	4741.1
...	con.	37.8	...	B	{ 37.8	...	...	...	...	B	{ 38.4	4737.7
...	spec.	42.2	...	...	/ 42.6	...	...	...	...	...	{ 41.1	4741.8
10	w D	44.01	10	w D	44.00	10	w D	43.67	...	...	...	4743.8
...	D	{ 42.2	...	...	...	...	...	...	...	D	{ 41.1	4741.7
...	...	45.4	...	...	...	...	...	...	...	...	{ 45.5	4745.7
...	head	45.43	...	head	45.21	...	head	45.43	...	head	45.5	4745.5
max	B	46.72	7	n B	46.38	4-5	B	46.70	max	B	47.05	4746.7
...	...	...	6	n B	48.32	...	...	...	...	...	...	4748.3
...	B	{ 45.8	...	...	...	...	...	...	...	B	{ 45.5	4745.5
...	...	(57.9)	...	...	...	...	...	...	...	...	{ 49.3	4748.9
1	n D	49.90	2-3	n D??	49.40	...	nn D?	49.49	...	...	...	4749.5
...	...	...	4	n B	50.43	...	...	...	...	...	...	4750.4
...	...	...	...	D??	...	...	...	...	10	w D	51.59	4751.6
...	...	...	5	n B?	55.16	...	nn B?	55.11	2	head	53.06	4753.0
...	...	...	...	n D??	56.06	...	...	...	...	n B	55.07	4755.3
...	...	...	3	n B?	56.93	...	nn B?	56.40	...	n D??	56.11	4756.1
...	B	{ 45.3	...	...	...	...	...	...	4	B	57.04	4756.8
...	...	58.3	...	...	...	...	...	...	...	...	...	4753.
2-3	n D	59.00	...	D?	...	...	wn D	58.90	3	n D	59.34	4758.0
...	...	...	3	n B??	60.07	...	...	...	2 4	n B	60.80	4758.9
...	...	...	...	n B??	62.93	...	...	...	3	B	63.37	4760.4
...	...	...	...	...	...	...	...	...	...	...	...	4763.2
...	...	...	...	...	...	...	...	...	...	...	...	{ 476
1	n D	66.55	...	nn D??	66.47	...	nn D	66.98	2	n D	66.54	4766.5
...	...	...	...	...	...	...	...	...	2	n B?	67.94	4767.9
...	...	...	...	...	...	...	...	...	1	n B?	69.58	4769.6
...	...	...	...	...	...	...	...	...	...	...	...	{ 476
1-2	nn D	72.70	1-2	nn D??	72.77	2	n D	72.15	...	D??	...	4772.7
...	...	...	...	nn B?	74.78	...	...	...	3 4	n B	75.18	4775.0
...	...	...	...	...	...	...	...	...	1-2	n D??	76.82	4776.8
...	B	{ 74.0	...	...	...	...	B	{ 73.2	...	...	...	4773.7
...	...	78.7	...	...	...	...	...	78.4	...	...	...	4778.3
2	n D	84.54	1	n D	84.78	...	nn D?	84.32	1	n D?	84.84	4784.5
1	n D	89.78	1-3	n D	89.67	1	n D	89.35	...	n D?	89.66	4789.5
...	...	...	...	...	...	max	B	94.37	...	B?	...	4794.4
...	...	...	...	...	...	...	B	{ 90.4	...	...	...	4790.3
max	B	02.27	...	...	...	...	...	96.2	...	...	...	4796.3
1-2	n D	06.89	...	wn D??	06.30	...	wn D	05.82	1	n D??	05.74	4802.4
1	n B?	11.34	...	...	...	2	n B?	10.20	...	...	...	4806.2
1	nn D	12.28	...	...	...	1	n D	11.72	...	...	...	4810.7
...	...	...	...	B??	...	2	n B?	13.92	...	...	...	4812.0
3	wn D	16.06	1-3	n D??	15.93	...	...	...	1-2	n D??	16.15	4814.0
...	B	{ (16.9)	...	...	...	...	B	{ 16.8	...	...	...	4815.9
...	...	21.7	...	...	...	...	...	22.1	...	...	...	4817.2
...	nn D	24.02	1	n D?	23.96	1	n D	23.27	1-2	n D??	23.86	4822.3
4	n B	26.29	1-2	B??	26.05	2	n B?	25.69	...	B?	25.85	4823.8
...	...	...	...	B	{ 24.7	...	...	...	...	B	{ 24.7	4826.0
...	...	...	...	27.1	...	...	...	...	...	...	26.9	{ 482
3	n D	28.31	2	n D?	28.19	1-2	n D	27.88	1-2	n D	27.90	4827.9
3 4	B	30.66	2 4	B	30.31	2 3	n B?	30.12	4 5	n B	30.56	4827.9
4 5	D	32.61	2-3	D	32.30	1-2	n D	32.48	4 6	D	32.46	4830.4
...	...	...	...	...	...	...	...	...	...	...	...	4832.5
1	nn D	40.27	0-1	n D??	39.45	...	...	...	...	n D??	38.93	4836.3
...	...	...	1	n D	43.50	...	...	...	1-2	n D	43.48	4839.5
...	...	...	...	...	...	...	...	...	1-2	n B	45.16	4843.4
...	...	...	...	B	{ 56.1	...	...	...	...	con.	56.7	4845.2
...	...	...	...	...	59.0	...	...	...	...	spec.	59.1	4856.4
1	nn D	51.97	1	n D?	51.40	...	nn D?	51.87	1	nn D	51.91	4859.1
1-2	n D	55.73	...	nn D??	55.19	...	...	...	...	...	...	4851.8
2	n B	57.76	max	B??	57.77	...	...	...	2-3	B	58.05	4855.5
1	nn D?	59.99	1	nn D??	59.29	...	...	...	1	n D	59.65	4857.7
2	nn B	61.45	...	...	...	max	B	61.46	1-2	n B??	60.72	4859.6
...	...	...	...	...	...	...	...	...	...	...	...	4861.3

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	288 Cassiopeia			19 Piscum			318 Birmingham			74 Schjellerup		
	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length
			t.m.			t.m.			t.m.			t.m.
279		B	{ 4860.1 4862.9									
281	3	n D	4865.11							1	nn D	66.1
281	3	nn D	(4865.11)							1	nn D	(66.11)
282												
283		nn D	4875.27					nn D?	71.83	1	n D	71.90
284								nn D	76.14		nn D	75.8
285												
286	max	B	(4878.53?)		B?							
287		B	{ 4876.6 4880.5									
288		nn D?	4882.07	2.3	n D	81.69	3	n D	81.55	2.3	n D	81.75
289												
290												
291												
292												
293		nn D?	4890.03							1	w D	90.9
294	max	B	4898.14							max	B	98.88
295		B	{ 4895.7 4899.8									
296	1-2	nn D	4900.70	2	nn D	00.81	2-3	n D	00.95		wn D	01.37
297												
298												
299												
300												
301												
302		nn D?	4920.65	1	n D	21.03		wn D	20.78		wn D	20.97
303												
304				1	n D?	24.91	1	nn D	25.24			
305							1	D	34.47		w D?	34.14
306												
307							1-2	n D	58.40			
308												
309												
310		head	5169.7		head	68.0		head	68.8			
311												
312				5	w D	73.57				3.4	D	73.21
313					B??		max	B	76.5			
314												
315		nn D	5183.83	1.5	D	83.65		nn D	83.72			
316											D	{ 81.7 85.5
317				1-2	B	87.31						
318								B	{ 85.5 91.7		B??	{ 85.5 91.4
319												
320												
321	2.4	n D	5193.81	3	D	93.06				4	D	93.03
322				1.2	n B	97.10				max	B	97.18
323												
324				1.2	n B??	04.02						
325								B	{ 94.8 04.5			
326												
327					w D	08.35						
328		w D	5200.97								D	10.19
329		D	{ 5204.3 5213.0					D	{ 04.9 11.7		D	{ 04.6 11.1
330				3.4	B	11.63						
331				1	n D	16.75	2	n D	16.53		D??	16.58
332				3	n B	18.75						
333								B	{ 17.5 24.6		B	{ 12.2 24.2
334	8	wn D	5226.19	6	wn D	26.19	6	wn D	26.33	6.8	wn D	26.17

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	
...	...	t.m.	...	...	t.m.	...	...	t.m.	...	...	t.m.	t.m.
...	...	...	...	...	...	...	B	{ 55.5 65.8	...	...	...	486
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...
1-2	B	69.82	1	n D??	67.74	1-2	n D	67.43	...	nn D??	65.09	4865.1
3	n D	71.57	2	n B??	69.26	...	...	...	3	n B	67.49	4867.7
1-2	n D?	75.56	2-3	n D??	71.43	...	...	...	...	n D	68.97	4869.4
...	...	...	...	n D??	75.52	...	...	...	2-4	n D	71.32	4871.6
1-2	n B	79.81	5	wn B??	79.45	...	...	...	2	n D	75.33	4875.6
...	...	...	...	...	...	...	...	...	...	nn D??	78.32	4878.3
...	...	...	...	...	...	...	...	...	2-3	n B	79.61	4879.6
...	...	...	...	...	...	...	...	...	...	...	...	{ 487
3	D	81.71	2-5	D	81.53	1	n D	81.09	4-7	D	81.52	4881.6
...	...	...	...	D??	...	...	...	...	4	n B	83.49	4883.5
...	...	...	...	...	...	...	...	...	3-5	n D	85.90	4886.0
...	...	...	...	...	...	...	...	...	...	D	{ 84.5 87.3	{ 488
...	...	...	...	...	...	...	...	...	2-3	n B	88.04	4888.0
...	nn D?	91.1	1-2	n D??	91.11	1-2	n D	89.88	1	n D	90.8	4890.3
3	nn B?	98.80	max	B??	98.90	...	...	...	3-8	n B?	98.70	4898.7
...	...	...	...	...	...	...	B	{ 93.2 101.4	...	B	{ 92.2 100.3	{ 4893
1	n D	01.34	1-2	n D?	00.67	2	D	01.87	3	n D	01.18	4900.5
...	...	...	...	...	...	...	...	...	5-6	n B?	03.78	4901.1
...	...	...	...	...	...	...	...	...	...	B	{ 02.3 04.9	{ 4903.8
...	...	...	...	...	...	...	...	...	3-4	wn D?	06.41	{ 490
...	...	...	...	B??	...	...	...	...	3-4	n B?	08.42	4906.4
...	...	...	...	nn D?	09.83	...	...	...	3-5	n D	10.59	4908.4
2-3	wn D	21.00	1	wn D??	20.52	1	nn D?	21.23	4	wn D??	20.54	4910.2
...	...	...	...	D	{ 19.1 21.5	...	...	...	4-5	...	...	4920.8
1	n D?	25.39	...	n D??	25.03	1	n D	24.91	...	...	...	{ 491
1	n D	33.81	2-3	n D?	34.01	...	...	...	...	...	...	4925.1
...	nn D?	57.60	2	n D??	58.05	...	...	...	1-2	n D	45.60	4934.1
...	...	...	wn D	82.02	...	...	wn D	81.05	2	n D??	57.68	4945.6
...	...	...	...	...	...	2	n D	67.24	...	...	...	4957.9
...	...	...	...	B??	68.04	...	head	68.2	...	head	67.6	4981.8
...	...	...	...	...	...	...	B?	68.2	...	...	...	5167.2
6	wn D	73.30	3-4	n D	72.85	4	n D	73.79	8	D	73.27	5167.9
...	...	...	...	...	...	...	...	...	2	B??	75.43	5172.8
...	...	...	...	...	...	...	B	{ 75.0 83.2	...	...	...	5173.3
1	n D	83.94	...	w D	83.50	2-5	n D	83.61	5-6	n D	84.08	5175.4
...	...	...	...	D	{ 81.2 85.2	...	...	...	...	...	...	{ 517
...	...	...	...	B?	...	...	B	86.7	7	B	87.36	5183.8
...	...	...	...	B	{ 85.2 91.9	...	B	{ 85.3 92.2	...	...	...	5181.5
1	n D	89.17	1	nn D??	89.23	1	n D?	89.43	...	D??	...	5185.4
...	...	...	...	B?	...	...	n B	90.80	2	B	90.97	5189.2
3	wn D	93.21	3	n D	93.04	2	n D	93.69	6	D	93.30	5191.8
...	...	...	...	D??	...	...	...	...	...	...	...	5189.9
...	...	...	...	...	...	...	...	...	1	D	92.43	5190.2
...	...	...	...	B	{ 94.3 104.1	...	B	{ 95.8 104.9	2	B??	93.85	5193.3
2	n D	05.84	...	...	...	...	...	...	2-3	n D	05.86	5197.1
...	...	...	...	D	{ 04.1 11.8	...	D	{ 05.0 13.0	...	...	...	5202.4
2	nn B?	14.22	...	B?	...	4	n B	14.35	5	B??	14.41	5203.9
1-2	n D?	16.68	1	nn D??	16.52	...	nn D?	16.67	5	n D	16.84	5194.9
...	...	...	...	B??	...	...	B	{ 18.0 25.0	4	B??	19.12	5204.5
...	...	...	...	...	...	...	...	...	...	...	...	5205.8
9	wn D	26.35	5	D	27.28	8	nn D	26.78	5	D	26.98	5208.4
...	...	...	...	...	...	...	...	...	...	...	...	5210.1
...	...	...	...	...	...	...	...	...	...	...	...	5204.6
...	...	...	...	...	...	...	...	...	...	...	...	5214.1
...	...	...	...	...	...	...	...	...	...	...	...	5216.7
...	...	...	...	...	...	...	...	...	...	...	...	5218.9
...	...	...	...	...	...	...	...	...	...	...	...	5221.6
...	...	...	...	...	...	...	...	...	...	...	...	5226.5

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	28 Sargis			19 Piscium			318 Birmingham			74 Schjellerup		
	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length
			Åm.			Åm.			Åm.			Åm.
335	...	...	...	2	B??	29.70	...	n B?	(29.81)	...	...	...
336	...	...	...	...	...	...	...	...	...	...	B	28.8
337	...	n D	5224.33	3	D	34.27	2 3	D	34.22	2	n D	33.3
338	...	...	...	...	...	...	...	...	...	...	n B?	33.95
339	...	...	...	1	D	39.94	2	n D	39.69	2	nn D?	37.06
340	...	...	...	...	B??	...	...	...	...	2-3	nn B??	40.12
341	2	n D	5247.48	5	D	47.56	2	n D	47.34	3	nn D	44.80
342	...	...	...	...	...	...	...	...	...	...	...	47.32
343	1	n D	5251.3	5	...	51.44	2 3	n D	51.28	2	n D	51.66
344	...	...	...	1	n D?	55.96	2	nn D	55.60	...	...	...
345	...	nn D?	5265.26	...	...	...	...	...	...	...	D?	65.55
346	1 5	n D	5270.62	6	D	70.46	5	n D	70.02	3	w D	70.17
347	...	...	...	2	n B??	79.59	2	n B??	79.68	...	...	...
348	2 3	n D	5283.24	1 2	n B?	83.17	...	...	...	1	n D	83.91
349	2	n D	5298.16	4-5	n D	98.19	4-5	n D	97.77	3	nn D	97.70
350	1	n D	5302.72	2	n D	02.76	1	nn D	02.24	1-2	n D	02.47
351	...	...	...	2 3	B	05.26	2-3	nn B	04.84	...	...	...
352	...	nn D	5307.97	...	...	...	...	...	...	1	nn D	07.17
353	...	...	...	2	n B	13.22	3	n B	12.98	...	...	...
354	...	nn D	5315.31	2	n B	15.27	2 3	n D	15.12	1-2	n D	15.30
355	...	...	...	4	n B	17.91	6	wn B	17.57	8	n B	17.50
356	...	nn D?	5320.95	2	n D	20.99	2	n D	(20.61)	...	...	...
357	...	...	...	1	n D??	25.32	...	...	...	...	...	...
358	...	w D	5329.80	5	w D	29.03	4	D	28.70	2 3	n D	29.00
359	...	nn D?	5337.05	1 2	n D	36.94	1	n D	36.83	2	n B?	36.65
360	...	...	...	3	n B	39.36	3	B?	39.05	4	n B??	38.70
361	1	n D	5341.84	2	D	41.30	4	D	41.25	2	n D	41.35
362	...	...	...	...	...	...	...	...	...	...	...	...
363	3-4	D	5350.43	3	wn D	50.07	...	...	...	2	n D	49.83
364	2	B	5353.37	2	n B	52.71	...	...	...	...	...	...
365	...	...	...	...	...	...	...	B	{ 51.1 61.1	...	...	...
366	...	...	...	1	D	62.99	...	...	...	...	nn D	61.89
367	...	...	...	2	n D	66.94	2	n D	66.47	1	nn D	66.35
368	...	...	...	2	B	68.78	3-4	n B	68.68	...	...	...
369	9	w D	5372.07	8-9	w D	71.70	6	D	71.50	6	w D	71.52
370	...	...	...	...	...	...	...	...	...	...	...	...
371	2-3	B	5375.22	6	B	75.38	7	n B	74.92	8	n B	74.76
372	...	nn D	5377.48	1-2	D	77.58	2	n D	77.36	2	n D	77.38
373	...	...	...	...	...	...	...	...	...	...	...	...
374	max	B	5380.54	2	n B	79.82	6-8	n B	79.72	6	n B	79.91
375	...	...	...	...	...	...	...	...	...	...	...	...
376	...	B?	{ 5378.0 5381.5	...	...	...	...	...	...	...	...	...
377	...	...	...	...	...	...	...	...	...	...	nn D?	84.69
378	...	nn D	5391.56	1	n D	91.09	...	...	...	...	D??	...
379	...	...	...	...	B?	...	...	...	...	3	n B?	93.01
380	...	...	...	...	...	...	...	...	...	...	...	...
381	5	D	5397.47	3	D	97.58	4	wn D	96.81	3	n D	97.28
382	...	...	...	2	B	04.06	max	B	03.72	...	...	...
383	...	B	{ 5399.9 5405.7	...	...	...	...	...	...	...	B	98.8
384	...	D?	5406.26	1	n D	06.43	...	...	...	1	n D	05.3
385	...	...	...	...	...	...	...	...	...	...	...	06.28
386	1	B?	5408.31	...	...	...	...	...	...	...	...	...
387	3	n D	5410.55	3	D	10.28	1	n D	10.37	3-4	n D	10.31
388	...	...	...	1 2	B	12.64	1	B	12.46	1	n B	12.32
389	...	...	...	1	D	14.45	1	n D	13.91	...	...	...
390	max	B	5418.34	7	B	17.29	...	w B	16.64	6	B	17.01
391	...	B	{ 5413.5 5419.4	...	...	...	...	...	...	...	...	...
392	2 3	n D	5420.44	2 3	n D	20.17	2 3	n D	20.22	3 4	n D	19.66
393	1 2	B??	5423.39	4	B	23.23	6	B	22.78	2-3	B	22.97
394	1	D	5425.90	1	D	25.24	1	nn D	24.82	...	...	...
395	1 2	B?	5427.39	3 4	B	27.99	5	n B?	(26.67)	2	n B	27.09
396	...	n D	5430.33	3	D	30.39	4	n D	30.13	3 4	n D	29.87

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			132 Schjellerup			MEAN WAVE-LENGTH
Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	
...	...	t.m.	...	...	t.m.	...	...	t.m.	...	...	t.m.	t.m.
...	...	...	...	...	...	...	B	30.73	6	B??	30.23	5229.2
...	...	...	...	...	...	...	B	{ 28.6	...	...	...	5228.7
...	...	...	...	...	...	...	B	{ 32.6	...	...	...	5233.0
3 4	n D	33.97	3	n D	33.91	2-3	n D	33.99	5	D	33.44	5234.0
...	...	...	max	B	36.52	6	wn B	36.70	10	B	36.22	5236.6
...	...	...	1	n D??	39.79	...	nn D	39.96	1-2	n D??	38.98	5239.8
...	...	...	...	B??	...	3	wn B	44.70	3	B??	44.87	5244.8
5	n D	47.43	3	n D	47.41	3	nn D	47.19	6	D	47.21	5247.4
...	...	...	...	...	...	...	...	...	5	B?	49.22	5249.2
3	n D	51.47	3	D	51.46	...	nn D	51.83	8	D	51.31	5251.5
1	nn D?	55.25	1	n D	55.60	...	...	...	2	D	55.31	5255.5
...	...	...	...	...	...	...	...	...	1	D	66.22	5265.7
3	n D	70.55	4-5	D	70.41	5	n D	70.75	5	D	70.05	5270.4
...	nn B?	79.75	1-2	B??	79.46	...	nn B?	80.10	2	n B?	79.47	5279.7
1	nn D	83.43	1	nn D??	83.90	...	n D	...	1-2	n D	84.33	5283.7
2	n D	97.63	3	D	98.11	2-3	D	98.37	2	n D	97.40	5298.0
2	n D	02.14	1	n D??	02.35	...	...	...	...	...	...	5302.4
1	n B	04.97	...	B?	...	...	nn B	05.13	...	B?	...	5305.1
2-3	nn D	07.44	...	...	...	...	...	...	...	...	...	5307.5
2 3	n B	13.07	...	B?	13.43	4	n B	13.13	4	B	13.20	5313.2
2 3	n D	15.09	1-2	n D	15.28	3	n D	15.30	3	D	15.40	5315.3
4	n B	17.58	2	B?	17.76	9	n B	17.81	1-2	B??	17.36	5317.6
...	nn D?	20.19	3	wn D??	21.13	3	nn D	20.71	...	...	...	5320.8
...	...	...	...	...	...	...	...	...	1	D	25.21	5325.3
3	n D	29.00	4	n D	29.06	...	...	...	3	D	28.54	5329.0
1 2	n B?	36.86	1	n D	36.82	4	n D	36.97	1-2	n D	37.30	5336.9
4	n B??	39.12	...	B??	...	6	n B	39.29	7	B	39.37	5339.1
2	D	41.59	...	n D	41.63	3	n D	41.78	7	D	41.61	5341.5
1	nn B?	44.64	2-3	...	...	...	nn B	44.71	6	B	44.31	5344.6
2-3	wn D	49.57	...	...	...	...	...	...	...	...	...	5350.0
1	n B	52.23	1	B??	52.52	4	n B	52.39	3-4	B??	52.25	5352.6
...	...	...	...	...	...	...	B	{ 55.4	...	...	...	{ 535
...	...	...	...	...	...	...	B	{ 64.8	...	...	...	5362.6
...	nn D	66.51	1	n D	62.90	...	...	...	1	n D	62.50	5366.5
3	n B	68.93	1-2	n D	66.72	1-2	n D	65.99	3-4	D	66.70	5368.9
6	n D	71.68	2	B	69.05	3	n B	68.71	10	B	69.11	5371.8
...	...	...	10	w D	71.89	7	wn D	71.64	9	D	72.10	5377.8
...	...	...	...	...	...	...	D	{ 70.1	...	...	...	{ 537
4-5	B	75.05	4-5	B	75.15	8	B	{ 73.7	...	...	...	5375.1
2	n D	77.38	1	n D	77.44	3	n D	75.01	8	B	74.98	5377.4
...	...	...	...	...	...	...	...	77.29	4	D	77.07	5378.9
5-6	wn B	80.47	3	n B??	80.46	9	wn B	80.68	3	B	78.92	5380.2
...	...	...	...	...	...	...	...	...	3	B	79.91	5381.4
...	...	...	...	...	...	...	...	...	...	n B	81.44	5378.3
...	...	...	...	...	...	...	B	{ 78.5	...	...	...	5382.2
...	wn D	84.87	1	n D	84.55	...	...	{ 82.1	...	...	82.9	5384.7
1	nn D	90.40	...	D?	...	...	...	...	...	...	...	5391.0
...	...	...	...	...	...	4-5	wn B??	93.21	...	...	...	5393.1
...	...	...	...	...	...	...	B	{ 87.5	...	...	...	{ 538
9	wn D	96.91	1	nn D	97.97	3	wn D	94.1	...	...	...	5397.3
...	...	...	...	...	...	...	...	96.75	3	D	97.88	5403.8
...	...	...	...	...	...	...	...	...	1-2	n D??	03.50	5399.4
...	...	...	...	...	...	...	B	{ 96.0	...	...	...	5405.5
...	...	...	1	nn D	06.90	...	...	{ 08.0	...	...	...	5406.5
...	...	...	...	...	...	...	...	...	2-3	wn D	08.30	5408.3
2	nn D	10.01	2	n D	10.59	3	n D	...	...	B?	...	5408.3
...	...	...	1-2	B	12.39	3	n B	09.80	...	...	...	5410.3
1	n D	14.40	1-2	n D??	14.09	1-2	n D	12.30	...	...	...	5412.4
7-8	n B	17.28	4-5	B	17.06	7 8	wn B	13.80	1-2	n D??	14.06	5414.1
...	...	...	...	...	...	...	...	17.00	...	...	...	5417.2
...	...	...	...	...	...	...	...	...	...	...	...	{ 541
3	n D	20.53	4	D	20.43	3	nn D?	20.49	2	n D	20.13	5420.3
2	n B	23.13	3	n B	23.05	3	n B	23.45	3	n B	22.50	5423.1
...	...	...	1-2	n D	25.03	...	nn D?	25.36	1	n D	24.41	5425.1
...	...	...	...	...	...	3	n B	27.18	...	...	...	5427.4
3	n D	30.27	3-4	D	30.33	3	D	30.17	2	D	30.24	5430.2

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	28 S. Group			19 Piscum			318 Birmingham			74 Schjellerup		
	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length
397	1	n B	t.m. 5432.68	2	B	t.m. 32.38	2	B	t.m. 32.13	1	n B	t.m. 32.14
398	2	n D	5434.66	1 2	D	34.20	1-2	D	33.99	2	n D	34.25
399	2	D??	5439.06	1	D	38.86	1	nn D?	38.06	...	...	...
400	...	...	...	...	...	...	...	...	...	...	...	...
401	...	...	...	4	B	45.19	...	...	...	...	...	...
402	...	B	{ 5440.7 5446.5	...	...	...	...	B	{ 39.2 45.7	...	B	{ 38.6 46.1
403	4	n D	5448.31	6	D	48.09	7-8	n D	47.72	5	n D	47.94
404	6	w B	5452.64	3	B	51.05	5	B	50.60	...	...	...
405	...	...	...	3	B	53.85	3	n B??	(53.02)	...	...	...
406	...	B	{ 5450.3 5455.0	...	...	...	...	...	...	...	...	...
407	4	n D	5456.54	3	D	56.96	2	n D	56.43	2 3	n D	56.54
408	1-2	B	5459.07	2	B	59.14	1	B	58.92	1 2	B	58.93
409	2	D	5461.13	2	D	60.99	2	n D	60.84	2	D	60.49
410	...	...	...	...	B	62.96	2	B	62.60	...	...	...
411	2 3	B??	5464.01	3-4	B	63.76	2	B	...	...	...	...
412	...	...	...	...	B	65.15	...	...	...	...	...	...
413	...	...	...	...	...	...	...	B	{ 61.3 65.7	...	B	{ 61.4 66.2
414	1	n D	5466.03	2	n D	67.83	2	n D	67.06	...	w D	67.60
415	...	...	...	...	D??	...	...	D?	{ 65.7 70.3	...	...	...
416	...	...	...	2-3	B	72.43	6	B	72.10	3	n B	71.77
417	1	n D	5475.08	1-2	n D	74.56	2	n D	74.38	2	nn D	74.33
418	...	...	...	1-2	n D??	78.09	2	n B??	77.56	1	n D	77.89
419	...	...	...	4	B	80.89	2-3	n B	(80.03)	4	n B?	80.25
420	1	nn D??	5483.08	2	D	82.73	1	n D	83.05	1-2	nn D	82.64
421	...	...	...	...	B??	...	...	...	...	...	...	...
422	...	...	...	3-4	D	98.13	...	...	...	3	n D	97.75
423	...	...	...	...	...	...	...	...	...	2	n D	01.81
424	...	...	...	...	...	...	...	...	...	...	...	...
425	...	...	...	...	head	03.1	...	...	...	...	...	...
426	...	...	...	1	D??	07.18	0 1	nn D	07.06	1	n D	06.66
427	1	n D	5507.19	2 3	n B	09.51	...	...	...	2	n B?	08.64
428	...	...	...	2	B	10.72	...	...	...	...	...	...
429	1	n B??	5510.00	...	...	...	...	...	...	...	...	...
430	...	con. spec.	{ 5508.6 5512.9	1-2	n D??	12.70	...	...	...	2	nn D	12.28
431	...	...	...	...	...	...	...	...	...	...	...	...
432	...	D	{ 5512.4 5517.9	...	...	...	...	...	...	...	...	...
433	...	con. spec.	{ 5518.2 5527.8	...	...	...	...	B	{ 13.8 23.0	...	...	...
434	...	...	...	1	n D	24.44	2	n D	24.35	1	wn D	24.19
435	...	...	...	...	...	...	...	...	...	...	...	...
436	2	n D	5528.85	1	D??	28.28	1	nn D??	29.09	...	...	...
437	2	n B?	5531.66	2	B	31.96	...	...	...	...	...	...
438	1	n D?	5533.79	1	D	33.87	1	n D	33.89	1	n D	33.66
439	...	...	...	7	wn D	39.73	8 9	n D	39.22	8	wn D	39.25
440	...	D	{ 5537.4 5542.4	...	...	...	...	...	...	...	...	...
441	...	...	...	...	head	41.8	...	head	41.4	...	...	...
442	...	...	...	4	B?	43.44	...	...	...	1-2	B	43.57
443	...	...	...	...	B	{ 41.8 47.0	...	B	{ 41.4 47.0	...	...	...
444	...	...	...	...	...	...	...	...	...	...	...	...
445	...	...	...	1	D	48.34	1-2	n D	48.31	...	...	...
446	...	...	...	1	D??	52.42	1	n D	52.53	1	nn D	52.20
447	max	n B	5554.54	3	B	54.29	2	n B	54.35	1	n B?	53.91
448	...	nn D?	5557.27	1	D	56.32	1-2	n D	56.28	1	n D	55.80
449	...	...	...	1-2	D	62.55	1-2	n D	62.68	...	...	...
450	...	...	...	2-3	B	64.49	2	n B	64.70	1 2	B	64.73
451	...	D	5567.60	2	D	66.60	1-2	n D	66.86	2	n D	66.57
452	...	...	...	1	D	70.29	1	n D	70.16	0 1	nn D	69.96
453	...	B??	5572.04	1	B	71.85	...	...	...	...	...	...
454	...	...	...	...	...	...	...	...	...	...	...	...

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	
		t.m.			t.m.			t.m.			t.m.	t.m.
2	n D	34.57	3	B	32.25	1	n B?	32.15	2	B??	32.23	5432.3
max	B	42.54	1-2	D??	34.35	...	...	...	1-2	n D	34.35	5434.3
			...	D??	...	...	...	...	2	D	38.93	5438.6
			...	B??	...	...	...	...	3	n B	42.70	5442.6
			...	B??	...	...	...	...	...	...	...	5445.2
	B	{ 39.7	...	...	...	...	B	{ 40.3	...	...	...	5439.8
		46.0	...	...	...	...	...	44.9	...	...	...	5446.0
9	n D	47.62	8	u D	47.73	7	n D	47.54	...	w D	47.06	5447.8
max	B	51.08	max	B	50.91	4-5	B	50.89	4	B	50.90	5450.9
			...	...	...	...	...	...	...	...	...	5453.9
	B	{ 49.0	...	...	...	...	...	...	...	...	...	5449.7
		55.1	...	...	...	...	...	...	...	...	...	5455.0
1-2	n D	56.81	3	n D	56.92	2	nn D	56.46	1	nn D	57.13	5456.7
1 2	n D	60.96	1-2	n D	60.99	1	n B?	58.88	...	...	...	5458.9
			...	...	...	1	n D	60.80	1	nn D	61.18	5460.9
			...	B?	...	...	...	...	...	...	...	5462.8
			...	...	...	...	...	...	...	...	...	5463.9
			...	...	...	...	...	...	...	...	...	5465.2
			...	...	...	...	...	...	...	...	...	5461.4
			...	...	...	...	...	...	...	...	...	5466.0
2	wn D	68.30	1	n D	66.75	...	...	...	...	...	...	5467.4
			...	...	...	...	...	...	...	...	...	{ 546
2	n B	72.63	3	B?	72.40	5	B	72.31	...	...	...	5472.3
1	nn D?	74.46	1	n D?	74.20	1-2	n D	74.34	1	D	74.35	5474.5
1	nn D?	78.25	1-2	n D??	78.04	...	...	...	...	...	...	5478.0
			...	B??	...	...	nn B?	80.91	1	B?	81.58	5480.9
1	n D	83.19	1	n D	82.99	...	nn D	83.60	...	...	...	5483.0
			...	...	...	...	nn B	86.18	1	B?	87.03	5486.6
3-4	D	98.22	1-2	n B?	95.65	...	...	...	...	...	...	5495.7
			5	D	97.92	...	...	...	...	...	...	5498.0
			4	n D	02.31	...	...	...	...	...	...	5502.1
	D	{ 96.8	...	...	...	...	...	...	...	...	...	{ 550
	head	{ 03.9	...	...	...	...	head	05.0	...	...	...	5504.
		03.8	...	...	...	...	...	...	...	...	...	5507.0
3	n B	09.59	1	n D??	06.89	...	...	...	5-6	B	08.30	5509.0
			2	wn B?	08.88	...	...	...	...	...	...	5510.4
			...	...	...	...	B?	{ 05.0	...	...	...	550
			...	...	...	...	...	{ 10.4	...	...	...	551
3	n D	12.44	2	nn D	12.46	2	nn D	12.20	...	...	...	5512.4
			...	...	...	...	...	...	...	...	...	{ 551
			...	con.	{ 13.9	...	B?	{ 14.5	...	...	...	5514.
			...	spec.	{ 23.2	...	...	{ 23.4	...	...	...	552
1-2	wn D	25.45	1	n D	24.36	nn D	23.95	...	...	...	...	5524.3
			...	...	...	n D	25.25	...	...	...	...	5525.4
			1	nn D??	28.09	...	...	...	...	...	...	5528.6
1	nn D?	(34.62)	1	n D	33.86	1	n D	33.96	1-2	wn D	32.6	5531.7
7	D	39.55	8	D	39.81	8	D	39.54	2 3	wn D	39.31	5533.9
			...	...	...	...	...	...	...	...	...	5539.5
			...	...	...	...	...	...	...	...	...	{ 553
	head	42.1	...	...	...	...	head	41.8	...	...	...	5541.8
			2 3	n B?	43.61	...	...	...	...	...	...	5543.5
	B	{ 42.1	...	B	{ 44.6	...	B	{ 41.8	...	...	...	5541.8
		47.3	...	...	46.7	...	...	46.7	...	...	...	5546.9
2	n D	48.60	1 2	D	48.03	2-3	n D	48.45	1 2	w D	46.56	5546.6
1	n D	52.45	...	...	...	1-2	D	52.80	1	D	52.64	5548.3
			...	...	...	2	n B	54.48	...	...	...	5552.5
1	n D	56.38	1	n D	56.30	2	n D	56.36	1	n D	56.24	5554.3
1	n D	62.76	1	nn D	62.20	1	n D?	62.40	1	n D	62.50	5556.4
			1 2	n B?	64.54	1-2	n B	64.87	...	...	...	5562.5
1-2	n D	67.23	1	n D	66.84	...	n D?	67.42	4	n D	68.08	5564.7
1	n D	70.36	...	...	...	max	B	71.24	...	...	...	5567.2
			2	B	71.66	...	...	67.7	...	...	...	5570.2
	B	{ 55.	...	...	...	...	B	73.1	...	...	...	5571.7
		73.6	...	...	...	...	...	...	...	...	...	{ 556.00

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

No.	280 Schjellerup			19 Piscium			318 Birmingham			74 Schjellerup		
	Inten- sity	Character	Wave-Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length
			t.m.			t.m.			t.m.			t.m.
455			.....	1	D	73.57	1	D?	73.9	1	D	73.41
456			.....								D??	
457	1-2	n D	5584.65	8-9	D	83.98	9-10	w D	83.70	9		83.98
458			.....		D	85.8			.....			.....
459			.....		head	85.8		head	85.6			.....
460	2	n B	5587.54	4	B	86.95	5	B	86.96	4	B	86.89
461	1-2	n D	5589.99	1-2	n D	89.32	1	D	89.14	1	n D	88.97
462			.....						.....			.....
463	1	n B	5593.21	1-2	n B	92.27	1	n B	92.53			.....
464			.....						.....			.....
465			.....	1	n D	94.51	1	n D	94.40	1	n D	94.62
466	2	n B?	5597.94	4	B	97.51	6-7	B	97.55	4	wn B	97.37
467			.....	1	n D?	99.60	1	n D	99.81	1	nn D	99.58
468			.....	2	n D??	99.33		wn D	99.74	2	n D	99.49
469			.....						.....			.....
470			.....	1	n D	15.56			.....			.....
471			.....	2	B??	17.38	2	B	17.42			.....
472	3	D	5620.92	2	D	20.07		nn D	20.31	3 4	D	20.20
473	4	D	5625.96	3	n D	24.71	5	n D	24.68	5	wn D	24.78
474			.....						.....		D	18.5
475			.....	1-2	B?	27.70	1	n B	27.76			26.1
476			.....						.....			.....
477	6	B??	5630.26	2	B?	30.69	1	n B?	30.54			.....
478		B	5627.9					B	26.1		B?	26.6
479	7	D	5632.0	10	D	34.21	10	w D	34.11	10	w D	32.2
480			5634.05						.....			34.20
481		head	5636.78		head	36.23		head	37.13		head	36.68
482			.....	3	B	37.59	2	n B	37.99			.....
483			.....	3	B	41.12			.....	2	n B	41.33
484			.....					B	37.1			.....
485		nn D	5645.22	1	n D	44.07	1	n D	43.74	2	n D	43.71
486			.....	2	n B??	46.75			.....			.....
487	1	n D?	5650.18	1	D??	49.88			.....	1	nn D	49.85
488			.....	2 3	B	53.00			.....			.....
489			.....	3	B??	55.10	max	B	55.42			.....
490		B	5651.3					B	45.1		B	44.8
491	1-2	n D	5657.2						56.4			57.2
492			5658.23	2	D	58.60			.....	3	n D	58.25
493			.....						.....			.....
494	1	n D	5671.71	1	D	70.83	1	n D	71.44	4	wn D	71.26
495	1	B?	5674.74	3	B??	73.75	4	n B	73.59	2	B?	74.35
496			.....						.....			.....
497	1 2	D	5677.33	1 2	D	76.41	1	n D	76.76	2	wn D	76.74
498			.....	1	n B	79.21			.....	1	B	79.24
499	1-2	nn D	(5687.93)	1	n B	84.29			.....			.....
500		nn B	5694.41	3	B	87.11	1	D?	(88.0)	1	nn D	86.89
501			.....	1	D	93.78		wn B	93.89	6	n B	93.62
502			.....	1	D	96.82	1	n D	97.24			.....
503	2	nn B	5706.71	3 4	D	105.41	5	n B	105.42	0 1	B?	100.26
504	1 2	n D	5708.92	2	D	108.29	4	n D	108.49	2	n D	108.44
505			.....	2	B	10.45	2	n B??	10.81	1	B	11.05
506			.....	1	D	12.94	2	n D	12.94	2	n D	12.88
507			.....	1	B	15.00			.....			.....
508		nn B	5717.37	4	B	17.05			.....	4	wn B	17.19
509			.....	4	B	17.87			.....			.....
510			.....					B	14.5			.....
511			.....						20.2			.....
512	2	n B	5724.44	1	n D	21.40	1	n D	21.95	2	n D	21.23
513		nn D	5731.70	1	B	24.12	1	n B	24.27	3	n B	24.07
				2	n D	31.20	3	n D	31.56	2	n D	31.76

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	Inten- sity	Character	Wave- Length	
		t.m.			t.m.			t.m.			t.m.	t.m.
1	n D	74.45	1	nn D?	73.4	...	...	...	...	...	...	5573.7
max	D	84.02	1	n D??	76.50	...	...	...	8	w D	76.16	5576.3
...	D	{ 73.6	9	D	83.86	9	D	83.83	10	w D	83.69	5584.0
...	head	{ 85.9	...	...	...	...	D	{ 81.9	...	...	...	5581.9
3	n B	86.03	...	...	...	...	head	86.21	...	...	...	5585.9
1	B	87.23	3	B	86.97	6	B	87.06	1	B?	87.57	5586.0
2-3	n B	89.27	1	n D	88.90	...	...	...	1	D	88.95	5587.2
...	...	92.10	1	n B	91.82	8	B	92.35	10	B?	91.44	5589.2
...	...	...	...	B?	...	...	B	{ 86.2	2	B	92.58	5591.4
2	n D	94.98	...	...	...	...	B	{ 93.5	...	...	...	{ 558
4	B	97.61	1	n D	94.41	...	n D	95.10	...	...	...	5594.7
1-2	nn D	00.38	2	n B	96.89	4	n B	97.67	...	...	...	5597.5
...	nn D	09.52	1-2	nn D	00.17	1	n D	00.03	...	...	...	5599.9
...	D	{ 07.6	1-2	nn D	09.05	...	wn D	09.83	...	...	...	5609.5
...	...	{ 12.1	...	...	...	...	D	{ 08.1	...	D	{ 06.9	5607.5
...	...	...	1	n D	15.42	...	...	{ 12.2	...	D	{ 16.0	5612.2
2	n D	20.18	1-2	n B?	17.11	...	...	...	1	D	16.09	5615.7
...	nn D	25.38	3	n D	20.00	...	nn D?	20.17	...	...	...	5617.3
...	D	{ 18.6	4	n D	24.61	...	nn D	25.64	...	...	...	5620.3
...	...	{ 27.1	...	D	{ 26.6	...	...	...	...	D	{ 18.8	5625.1
...	...	...	...	B??	26.5	...	...	...	...	...	{ 25.4	5626.2
...	...	...	...	...	...	...	...	...	...	...	...	5627.7
...	...	...	...	...	...	...	...	...	...	w B??	29.00	5629.0
...	...	...	...	con.	{ 26.50	...	...	...	...	...	...	5630.5
...	...	...	...	spec.	{ 31.40	...	B	{ 32.3	...	...	...	5626.9
10	D	34.23	10	D	33.79	10	D	34.58	10	w D	33.76	5631.8
...	...	...	...	...	...	...	D	{ 32.3	...	...	...	5634.1
...	head	36.79	...	head	36.60	...	head	{ 37.6	...	...	...	{ 5630
8	n B	38.64	2-3	n B	37.87	...	...	37.49	...	head	36.11	5636.9
6	B	41.65	2-3	n B	40.74	...	...	...	6	B	38.06	5638.0
...	B	{ 36.8	...	...	...	...	B	{ 43.6	4	B	41.46	5641.3
2	n D	44.29	...	wn D	43.89	...	nn D	45.20	...	...	...	5637.2
1	nn D	50.24	1-2	n B?	46.15	...	n B	46.21	1	n D	44.57	5642.8
2	n B?	55.24	...	...	...	...	...	...	...	...	...	5644.3
...	...	...	1	n B?	55.42	max	B	55.30	...	...	...	5646.4
...	...	...	...	...	...	...	B	{ 46.3	...	...	...	5650.2
1	nn D	57.63	1	n D	57.93	...	nn D	56.7	...	...	...	5653.0
...	...	...	...	...	...	...	B	{ 59.2	0 1	D	57.32	5655.2
3	n D	71.34	1	nn D	70.99	1 2	n D	71.68	...	...	...	5645.4
2	n B?	73.93	...	B??	...	2	n B	74.3	1	nn D	71.22	5656.9
2	n D	76.47	1	n D	76.48	1	n D	76.67	...	...	...	5658.0
1-2	n B?	79.45	...	B??	...	2	n B	79.96	...	...	...	{ 565
2	n B?	83.81	...	...	...	2	n B	84.21	2	B	79.49	5671.3
...	...	86.53	1	n D	86.29	...	...	...	4	D	86.59	5674.1
8	wn B	93.79	4	B	93.21	8	n B	94.16	5	B	93.17	5676.7
1	nn D	96.33	1	nn D	96.72	1	n D?	97.18	1	D	95.80	5679.5
...	...	...	...	...	...	2	n B	99	...	B??	...	5684.1
5	n B	05.05	3	B	04.53	6	n B	05.14	1 2	B	04.97	5686.6
3-4	n D	08.03	2	n D	08.23	1	n D?	08.09	2	D	07.89	5693.8
...	...	13.19	1	B??	10.71	...	...	...	...	B??	...	5696.7
8	wn B	17.23	1-2	n D	12.33	1	n D?	13.12	1	n D	12.49	5699.8
...	...	...	5	nn B?	16.31	8	n B	17.17	8	B	16.49	5705.3
...	...	...	...	B	{ 14.1	...	...	...	...	...	...	5707.8
2	n D	21.46	...	...	{ 19.6	...	...	...	...	...	...	5710.8
6	wn B	24.28	1	n D	21.5	...	...	...	4	n D	20.68	5712.8
8	n D	31.48	3	n B?	21.00	8	n B	24.86	6	B	23.80	5715.0
...	...	...	3	D	30.72	2	n D	31.97	6	w D	31.60	5717.0

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY *Continued*

No.	28 <i>Serpentis</i>			19 <i>Piscium</i>			318 <i>Berenicium</i>			74 <i>Schjellerup</i>		
	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length	Intensity	Character	Wave-Length
			t.m.			t.m.			t.m.			t.m.
514	..	..	..	..	..	..	..	..	..	..	D	{ 26.6 33.4
515	..	B	{ 5734.2 5743.1	..	..	..	..	B	{ 33.8 41.7	..	..	..
516	..	nn D	5744.32	2	n D	44.35	..	nn D	43.89	1	nn D?	43.96
517	..	..	..	1	n B??	47.09	..	..	..	..	..	..
518	..	..	..	1	n D	49.59	..	nn D	49.73	..	..	..
519	..	..	..	..	..	..	..	..	..	..	..	..
520	1	n D	5751.70	..	..	..	..	..	..	..	..	..
521	2-3	wn B	5758.05	3	n B	57.02	max	B	57.08	..	..	..
522	..	..	..	..	..	..	..	..	..	..	..	..
523	..	wn D	5763.7	2	n D	62.53	..	nn D	62.53	1	n D	63.66
524	2	n B	5768.79	2	n B?	67.29	..	..	..	..	..	..
525	1	n D	5772.1	2	n D	71.19	..	nn D	71.35	..	wn D	71.59
526	..	..	..	..	..	..	..	..	..	..	..	..
527	1	n B?	5775.81	..	..	..	..	..	..	..	..	..
528	..	..	..	1	n D??	77.82	1	n D	78.48	1	nn D?	77.86
529	2	n B	5780.77	1-2	B	79.86	..	..	..	..	..	..
530	..	..	..	..	..	..	..	..	..	..	B	{ 73.5 82.0
531	2	n D	5785.57	..	..	..	2	wn D	84.41	..	..	..
532	..	..	..	..	..	..	..	..	..	..	..	..
533	..	..	..	..	..	..	..	..	..	..	..	..
534	..	..	..	..	..	..	..	..	..	..	D	{ 82.0 91.3
535	..	..	..	1	D	98.68	1	nn D?	99.1	1	nn D	98.50
536	..	..	..	1	n D	22.69	..	..	..	2	n D	22.92
537	..	..	..	..	..	..	1	n D	48.46	..	..	..

WAVE LENGTHS OF LINES IN THE VIOLET REGION OF 19 *PISCUM*

As already stated, the violet region of 19 *Piscium* was photographed with a one-prism spectrograph attached to the two-foot reflector (Figs. 1 and 2, Plate XI). With the light flint prism and the very short camera of this spectrograph, the scale of the resulting spectrum was too small to permit of precise determinations of wave-length. The results of the measures of plates R 34, 37, and 38 by Mr. Parkhurst are nevertheless valuable, as they permit some of the important lines to be identified, and in fact furnish the only knowledge we have of the positions of lines in this part of the spectrum of fourth-type stars.

Three plates were measured, the numbers, exposure times, and range of spectrum in which the lines were good enough to measure being:

Plate	Exposure	Lines Measured
R 34 .....	5 <sup>m</sup> 39 <sup>sec</sup>	4255 to 4327
37 .....	7 45	4079 to 4380
38 .....	24 40	3969 to 4373

The wave-lengths of the star lines on the long-exposure plate R 38 could not be deduced directly from the plate, since there was a shift of the comparison lines due to the exposure being extended over four nights. Therefore a correction was made to the wave-lengths of R 38, deduced by comparison with seven of the best star lines common to R 37 and R 38. This correction, for the seven lines, varied from 2.8 to 6.4 t.m., so that the mean is uncertain by as much as 2 t.m. The uncertainty

TABLE OF MEAN WAVE-LENGTHS CORRECTED FOR RADIAL VELOCITY—Continued

78 Schjellerup			132 Schjellerup			115 Schjellerup			152 Schjellerup			MEAN WAVE-LENGTH
Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	Intensity	Character	Wave- Length	
		t.m.			t.m.			t.m.			t.m.	t.m.
...	...	...	...	...	...	...	...	...	...	D	{ 33.9	{ 572
...	...	...	...	B	{ 33.0	...	B	{ 33.5	...	B	{ 33.9	{ 5733.8
...	...	...	...	{ 41.4	...	{ 42.6	...	{ 41.3	...	{ 41.3	...	{ 5742.0
3	n D	43.02	1	nn D	43.60	1	n D?	43.73	2	D	43.26	5743.8
...	...	...	...	...	...	...	...	...	2	B?	46.06	5746.6
2	nn D	49.85	1-2	nn D	49.43	1	n D	48.83	3	D	48.98	5749.4
...	D	{ 42.2	...	...	...	...	...	...	...	...	...	{ 574
...	...	{ 50.8	...	...	...	...	...	...	...	...	...	{ 5751.7
...	...	...	2	n B?	56.23	max	B	57.55	2	n B	56.41	5757.1
...	...	...	...	...	...	...	B	{ 53.0	...	...	...	{ 575
...	...	...	...	...	...	...	...	61.4	...	...	...	{ 5762.6
3	n D	62.23	2	n D?	61.72	1	n D	62.95	...	...	...	{ 5767.5
...	...	...	1-2	B?	66.82	3	n B	67.63	1-2	B	67.09	5771.1
3	n D	70.71	...	...	...	nn D	71.39	2	D	70.10	...	5773.3
...	...	...	...	B?	...	...	...	3	B	73.33	...	5776.1
...	...	...	...	...	...	1-2	n B?	76.41	...	...	...	5778.1
...	...	...	...	D?	...	...	...	...	...	...	...	5780.3
...	...	...	1-2	B?	79.65	2	n B	80.87	4	B	80.11	5772.3
...	B	{ 71.9	...	B	{ 71.5	...	...	...	...	...	...	5781.1
...	...	{ 80.5	...	...	{ 80.9	...	...	...	...	...	...	5784.8
3	wn D	85.23	...	...	...	wn D	84.81	5	w D	84.11	...	{ 578
...	...	...	...	D	{ 80.9	...	...	...	...	...	...	{ 5789.7
1	nn D?	89.93	...	D?	{ 86.7	...	...	...	1	D	89.40	{ 578
...	...	...	...	...	...	...	...	...	...	...	...	{ 578
2	n D	97.61	1	n D	97.60	...	...	...	1	n D	97.32	5798.1
1	nn D	23.44	2	n D	22.11	...	...	...	1	D	22.09	5822.7
1	n D	49.82	...	...	...	...	...	...	...	...	...	5848.6

of the adopted wave-lengths is increased by the poor quality of the comparison lines on R 37, which has the best star lines.

The star line  $H\delta$  is nebulous on plate R 38, and apparently 5 t.m. wide; the uncorrected wave-length is 4103.5; corrected wave-length, 4100.4. On plate R 37 the line seems quite narrow and sharp, the wave-length being 4100.5. The correction to reduce to the wave-length in the Sun, +1.5 t.m., is within the errors of measurement.

The mean wave-lengths from the three plates are given in the following table:

 LINES IN THE VIOLET REGION OF  $\eta$  PISCUM

Plates R 34, 37, and 38

Intensity	Character	No. Plates	Wave- Length	Solar Lines	Intensity	Character	No. Plates	Wave- Length	Solar Lines
Spec.	begins	..	393	K	...	Limits	..	{ 4224.4	
...	wn D	1	3967.0	H 3968.6 Ca	...	n D	1	{ 4233.3	
...	nn D?	1	4004.4	...	...	nn D	2	4254.4	
...	nn D	1	4018.3	...	1	n D	1	4274.0	
1	n D	1	4034.8	...	...	n D	3	4282.8	
3	n D	1	4058.2	...	...	w D	2	4289.0	
...	nn D	2	4078.7	...	...	...	...	{ 4303.5	G group
4	n D	2	4100.5	$H\delta$ 4102.0	...	nn D	2	{ 4312.6	
...	nn D?	2	4132.3	...	3	D	1	4325.9	
...	wn D	1	4145.4	...	2	D	1	4340.4	$H\gamma$ 4340.6
...	nn D?	1	4197.5	...	2	D	1	4354.2	
10	D	2	4227.6	Ca 4226.9	6	D	1	4363.4	
								4383.7	

## WAVE-LENGTHS OF LINES IN THE RED REGION OF 152 SCHJELLERUP

Plate G 211, taken on an Erythro plate with camera No. 2 and a single dense flint prism, gives the approximate positions of the lines in the red and orange region of the spectrum of 152 *Schjellerup*. The following measures were made by Mr. Ellerman. On account of the small scale of the spectrum in this region, they may be considerably in error, but they suffice for the identification of some of the strongest lines. This photograph is reproduced in Plate VI.

## LINES IN THE RED REGION OF 152 SCHJELLERUP

Plate G 211

Intensity	Character	Wave-Length	Remarks
		t.m.	
2	B	5592.4	End of zone
..	D	5731.1	
2	D	5748.9	
1	B?	5757.4	
1	B?	5778.2	
1	n D	5808.4	
..	B?	5845.3	Very n
10	D	5894.3	Sodium, D <sub>1</sub> and D <sub>2</sub>
1	n D	5921.9	
1	D	5945.9	
1	B	6020.8	
1	B	6050.0	
1	n D	6059.1	
..	B	6086.1	Brightest part of bright band
3	D	6098.5	
7	B	6108.4	
2	D	6119.0	
8	B	6130.5	Double?
2	B	6154.9	
10	B	6176.0	
2	D	6190.3	
10	B	6200.9	
..	B	{ 6222.1	Band increasing { from
..	B	{ 6253.4	
10	D	6269.6	Very broad
1	B	6310.8	
1	B	6330.2	
3	D	6357.6	
..	D	6425.3	Center of broad, hazy band
3	B	6444.8	
..	...	6488.2	Spectrum drops off here, dark space
..	...	6587.5	to
..	...	6631.	end of faint continuous spectrum

## PRECISION OF THE MEAN WAVE-LENGTHS

The sources of error in this investigation are numerous, and render it impossible to secure a high degree of precision in the results. In the spectrograph the wide slit necessarily employed, the instability of the prism supports, and the variations in temperature of the prisms during the long exposures, tended to produce wide and diffuse lines on the photographs, and to introduce irregular displacements of unknown magnitude. In comparison with these sources of error, which affect both stellar and comparison spectra, all errors due to the measuring machines or to the method of reduction are comparatively unimportant and may be neglected. During the progress of this research the old spectrograph was used by Messrs. Frost and Adams for the measurement of stellar motions in the line of sight. Most of this work was confined to bright stars having well-defined lines in their spectra. But, in spite of the short exposures required for such objects, errors arising from unknown causes were frequently apparent in the results. For example, the star  $\epsilon$  *Leonis*, as photographed on seventeen occasions between February 11 and April 25, 1900, gave velocities ranging from -10 to +13 km. This led to the belief that  $\epsilon$  *Leonis* varied in its radial velocity, but it was afterward shown that the star has an apparently constant radial velocity of about 5 km. On many other occasions, however,

the spectrograph gave excellent results, agreeing well among themselves and with recent determinations for the same stars made with the Bruce spectrograph. On account of the uncertain behavior of the instrument, it is impossible to base conclusions regarding the precision of our own results upon the contemporaneous observations of known stars by Messrs. Frost and Adams.

A source of error which undoubtedly affected seriously our determinations of radial velocity, giving rise to the widely different values obtained for different lines, is the physical condition of fourth-type stars. As will be shown later, the spectra of these stars differ widely from the solar spectrum, partly through marked changes in the relative intensities of the dark lines, and partly through the presence of bright lines. Both of these causes greatly complicate the determination of radial velocity, and thus introduce errors which appear later in the corrected wave-lengths.

An idea of the precision of the measures may be obtained from the following table, which gives the average deviation of the wave-length of a line in one star from the mean for six, seven, and eight stars. The number of lines used is given in parenthesis after each deviation.

## PRECISION OF THE MEASURES

## AVERAGE DEVIATIONS

No. of Stars	Blue Region	Yellow-Green Region	Both Regions
	t.m.	t.m.	t.m.
6 .....	0.15 (29)	0.28 (28)	0.22 (57)
7 .....	0.17 (22)	0.22 (24)	0.20 (46)
8 .....	0.22 (19)	0.23 (30)	0.23 (49)
Means. ....	0.18 (70)	0.25 (82)	0.22 (152)

The probable error of the mean averages 0.07 t.m.

In such a comparison it is of course assumed that the wave-length of a line does not vary from star to star. That this assumption is in some degree warranted is shown by the residuals at the foot of the following table, which contains the wave-lengths of the forty-nine dark lines measured in all of the stars, with their average deviations from the mean.<sup>28</sup> These results also give a final check on the adopted values of the velocities of motion in the line of sight, as the mean wave-lengths should agree if the velocities were correct. The actual residuals, ranging from  $-4$  to  $+4$  km. (mean  $\pm 2.3$  km.), show that the adopted values are not greatly in error. The stars in the table are arranged in the assumed order of development (Plate IX).

## LINES MEASURED IN ALL OF THE STARS

	280 Schj.	19 Pisc.	318 Birm.	74 Schj.	78 Schj.	132 Schj.	115 Schj.	152 Schj.	Means	a. d.
4435.22		35.52	35.49	35.72	35.92	35.60	35.47	35.97	35.61	0.19
4501.22		01.78	01.87	01.97	01.87	01.92	00.91	02.15	01.71	0.29
4506.38		06.77	07.08	07.04	07.09	07.12	06.74	07.24	06.93	0.22
4512.83		12.76	12.64	12.30	13.08	12.83	13.05	12.81	12.79	0.16
4518.15		18.27	18.31	18.38	18.53	18.35	18.21	18.23	18.31	0.09
4522.91		23.00	23.06	23.20	23.23	23.17	23.08	23.21	23.11	0.10
4535.30		35.84	35.84	35.90	35.70	36.04	35.56	36.21	35.67	0.24
4560.11		60.39	60.42	60.48	60.47	60.23	60.35	60.21	60.34	0.11
4606.26		06.87	06.86	06.88	07.20	06.83	06.24	06.38	06.69	0.27

<sup>28</sup> Out of 537 catalogued lines and spaces, only 49 were common to all the 8 stars. The reasons for this are as follows:

1. The appearance of any given line varied greatly with exposure time and temperature changes, so that it might be unmistakable in character on one plate and so indefinite as to be left unmeasured on another, as the choice of lines to be measured was made independently on each plate.

2. Lines marked doubtful on both plates of a star were not catalogued unless unmistakable in character in other stars.

3. Plates of the faint stars 280 Schj., 74 Schj., and 115 Schj. contained comparatively few lines, and at the same time the proportion of doubtful lines on these plates was greater than the average.

By this process of exclusion the number of lines common to all the stars was greatly reduced, though the number measured in 5 or 6 stars was much greater.

LINES MEASURED IN ALL OF THE STARS *Continued*

	19 Disc.	318 Birm.	74 Schj.	78 Schj.	132 Schj.	115 Schj.	152 Schj.	Means	a. d.
4617.74	17.80	18.03	17.99	18.09	18.23	17.74	18.15	17.97	0.15
4619.29	19.68	19.86	19.70	19.85	19.56	19.42	19.40	19.60	0.19
4638.03	38.75	39.19	39.03	39.15	39.07	38.78	38.96	38.87	0.26
4766.78	66.11	66.47	66.33	66.55	66.47	66.98	66.54	66.50	0.18
4822.75	23.91	23.86	23.51	24.02	23.96	23.27	23.86	23.64	0.45
4826.52	27.81	28.21	28.23	28.31	28.19	27.88	27.90	27.88	0.46
4832.49	32.51	32.56	32.57	32.61	32.30	32.48	32.46	32.48	0.07
4882.07	81.69	81.55	81.75	81.71	81.53	81.09	81.52	81.61	0.19
4900.70	00.81	00.95	01.37	01.34	00.67	01.87	01.18	01.11	0.33
4920.65	21.03	20.78	20.97	21.00	20.52	21.23	20.54	20.84	0.22
5226.19	26.19	26.33	26.17	26.35	27.28	26.78	26.98	26.49	0.31
5234.33	34.27	34.22	33.95	33.97	33.91	33.99	33.44	34.01	0.20
5247.48	47.56	47.34	47.32	47.43	47.41	47.19	47.21	47.37	0.10
5251.30	51.44	51.28	51.66	51.47	51.46	51.83	51.31	51.47	0.15
5270.62	70.46	70.02	70.17	70.55	70.41	70.75	70.05	70.38	0.22
5298.16	98.19	97.77	97.70	97.63	98.11	98.37	97.40	98.00	0.20
5315.31	15.27	15.12	15.30	15.09	15.28	15.30	15.40	15.26	0.09
5337.05	36.94	36.83	36.65	36.86	36.82	36.97	37.30	36.93	0.14
5341.84	41.30	41.26	41.35	41.59	41.63	41.78	41.61	41.54	0.19
5372.07	71.70	71.50	71.52	71.68	71.89	71.64	72.10	71.76	0.19
5377.48	77.58	77.36	77.38	77.38	77.44	77.29	77.07	77.37	0.10
5380.54	79.82	79.72	79.91	80.47	80.46	80.68	79.91	80.19	0.35
5397.47	97.58	96.81	97.28	96.91	97.97	96.75	97.88	97.33	0.39
5420.44	20.17	20.22	19.66	20.53	20.43	20.49	20.13	20.26	0.21
5430.33	30.39	30.13	29.87	30.27	30.33	30.17	30.24	30.22	0.11
5448.31	48.09	47.72	47.94	47.62	47.73	47.54	47.06	47.75	0.28
5456.54	56.96	56.43	56.54	56.81	56.92	56.46	57.13	56.72	0.23
5461.13	60.99	60.84	60.49	60.96	60.99	60.80	61.18	60.92	0.16
5475.08	74.56	74.38	74.33	74.46	74.20	74.34	74.35	74.46	0.19
5557.27	56.32	56.28	55.80	56.38	56.30	56.36	56.24	56.37	0.23
5567.60	66.60	66.86	66.57	67.23	66.84	67.42	68.08	67.15	0.43
5584.65	83.98	83.70	83.98	84.02	83.86	83.83	83.69	83.96	0.19
5587.54	86.95	86.95	86.89	87.23	86.97	87.66	87.57	87.22	0.28
5634.05	34.21	34.11	34.20	34.23	33.79	34.58	33.76	34.12	0.24
5645.22	44.07	43.74	43.71	44.29	43.89	45.20	44.57	44.34	0.48
5671.71	70.83	71.44	71.26	71.34	70.99	71.68	71.22	71.31	0.23
5694.41	93.78	93.89	93.62	93.79	93.21	94.16	93.17	93.76	0.31
5706.71	05.41	05.42	05.25	05.05	04.53	05.14	04.97	05.31	0.29
5731.70	31.20	31.56	31.76	31.48	30.72	31.97	31.60	31.60	0.14
5744.52	44.35	43.89	43.96	43.02	43.60	43.73	43.26	43.77	0.37
Means.....	5150.86	50.78	50.74	50.72	50.85	50.77	50.84	50.79	0.23
Residuals t.m....	+0.07	-0.01	-0.05	-0.07	+0.06	-0.02	-0.05	.00	.....
" km....	+4	-1	-3	-4	+3	-1	-3	0	±02.3

## THE CARBON BANDS

Since the time of Secchi the characteristic dark bands of fourth-type stars have been attributed to some form of carbon. For the reasons mentioned by Dunér,<sup>27</sup> the measures of Secchi, though they appear to be sufficient to identify the bands, can be given but little weight. The measures of Vogel and Dunér have therefore formed the only reliable basis of comparison. The means of these measures, compared with the wave-lengths of the heads of the carbon bands, are as follows:

Star	Carbon Band	Star Laboratory	
t.m.	t.m.	t.m.	
437	4381.93	-10. ±	Edge of violet band
4729	4737.18	- 8.	Edge of blue band
5162	5165.30	- 3.	Edge of green band
5633	5635.43	- 2.	Edge of yellow band

While the differences are in some cases considerable, these measures leave no doubt that the dark bands of the fourth-type stars correspond with the bands of the Swan spectrum. The systematic shift toward the violet of the bands in the star is presumably due to a physiological effect arising from the presence of the bright zones on their less refrangible edges. The largest errors naturally correspond to the faintest bands.

As our photographs show not only the principal heads, but also the secondary heads of the flutings, a careful comparison with the carbon flutings in the electric arc seemed desirable. Photographs of the various bands, compared with photographs of the bands of the carbon arc, are reproduced in Plate VII. From these it will be seen that the fluted structure of the bands is repeated in the stars with perfect fidelity.

The following table contains the mean wave-lengths of the heads of the various flutings, as derived from all of our measures; the number of stars in which each fluting was measured; the maximum and average deviation from the mean wave-length in all of the stars measured; the assumed origin of the flutings; the wave-lengths of the flutings as measured by various investigators in the laboratory; and the differences between the star and laboratory determinations. In these last comparisons the wave-length determinations of Crew and Basquin are used for the cyanogen flutings, and those of Kayser and Runge for the flutings of the Swan spectrum.

HEADS OF THE CARBON FLUTINGS				WAVE-LENGTH IN LABORATORY					$\Delta\lambda$ , LABORATORY		
Mean Wave- Length in Stars Corrected for Slit-Width	No. of Stars	Deviation from the Mean		Origin	Eder and Valenta	Fievez	Hassel- berg	Kayser and Runge	Crew and Basquin	Kayser and Runge	Crew and Basquin
		Maximum	Average								
		t.m.	t.m.		t.m.	t.m.	t.m.	t.m.	t.m.	t.m.	t.m.
4380.6	...	...	...	Swan Spec.	4380	...	...	...	...	...	...
4503.2	5	0.5	0.2	CN	...	...	...	...	4502.35	...	+0.9
4515.0	2	0.4	0.4	CN	...	...	...	...	4514.95	...	0.0
4532.6	4	0.4	0.4	CN	...	...	...	...	4532.06	...	+0.5
4555.3	5	0.1	0.3	CN	...	...	...	...	4553.31	...	-2.0
4578.4	6	0.6	0.5	CN	...	...	...	...	4578.19	...	-0.2
4608.8	6	0.6	0.3	CN	...	...	...	...	4606.33	...	-2.5
4697.2	1	...	...	Swan Spec.	4697.66	...	4696.2	4697.57	...	...	-0.4
4716.5	4	(1.3) <sup>30</sup>	0.2	"	4715.73 <sup>30</sup>	...	4713.7	4715.31	...	...	+1.2
4738.6	7	0.6	0.2	"	4737.25	4736.3	4735.7	4737.18	...	...	+1.4
[5169.1] <sup>30</sup>	3	(1.8) <sup>30</sup>	0.4	"	...	5165.6	5165.4	5165.30	...	...	...
5505.4	3	0.9	0.7	"	...	5504.6	5501.6	...	...	...	...
5543.5	4	0.4	0.2	"	...	5543.3	5538.5	5540.86	...	...	+2.6
5587.7	3	0.2	0.1	"	...	5581.5	5586.2	5585.50	...	...	+2.2
5638.8	8	0.8	0.4	"	...	5635.0	5637.5	5635.43	...	...	+3.4
Mean, 0.3										Mean Shift, +1.4 t.m.	

As the average deviation from the mean for a single star is only 0.3 t.m., while the mean shift of the heads of the flutings is 1.4 t.m. toward the red, there would appear to be some actual shift of the flutings in the star. The mean of Vogel's and Dunér's wave-lengths, as given above, indicates a somewhat larger shift toward the violet. It should be remembered, however, that these observations were made visually with very limited instrumental means, which did not permit a high degree of precision to be attained. Dunér's measures of the heads of the carbon flutings, for example, show the following range, which is surprisingly small, in view of the circumstances under which they were made:

132	Schjellerup	5640	5168	4715
132	Schjellerup	5634	5161	4730
152	Schjellerup	5625	5169	4721
152	Schjellerup	5635	5165	4740

<sup>30</sup> End of plate; too faint for precise measurement.

Our measures of these heads for the same stars are:

132	<i>Schjellerup</i> .....	5638.7	5169.5	4738.7
132	<i>Schjellerup</i> .....	5638.2	5169.0	4738.5
152	<i>Schjellerup</i> .....	5638.1	5169.1	4739.2
152	<i>Schjellerup</i> .....	5637.8	5168.6	.....

It is therefore evident, as might be expected from the use of photographic methods with a much more powerful telescope, that the precision of our determinations of the positions of the flutings is considerably higher than that of Dunér's measures. But it is nevertheless unsafe to conclude that the apparent shift of the flutings in the stars is actually due to some peculiarity of their carbon radiation; for, even with all the advantages of such determinations, the differences between the wave-lengths measured in the laboratory by excellent observers are quite as great as the differences between our wave-lengths for the stars and the laboratory determinations of Kayser and Runge. The measurement of the edge of a more or less diffuse band is always liable to error. But in the fourth-type stars the difficulty of measurement is greatly increased by the presence of closely adjoining, or even overlapping, bright and dark lines. Thus the lines of the *b* group have prevented us from obtaining a satisfactory measure of the head at  $\lambda$  5165. Under these circumstances we are not inclined to adopt the conclusion that the carbon flutings in the fourth-type stars are actually displaced from their normal positions.

The long discussion on the origin of the Swan spectrum, which has played so conspicuous a part in the literature of spectroscopy, cannot be said to have terminated. This is hardly an appropriate place to present the numerous arguments advanced by the supporters of the various views which are still entertained. The assignment of these bands to carbon monoxide by Smithells,<sup>41</sup> with its subsequent confirmation by Baly and Syers,<sup>42</sup> seemed for a time to set the matter at rest. But the recent work of Konen<sup>43</sup> has revived the discussion. Konen investigated the spectrum of the electric discharge in various liquids containing carbon, and obtained the Swan spectrum in many cases when every precaution had been taken to exclude oxygen. He is therefore inclined to the belief that the Swan spectrum is due to carbon alone, though he admits that if the discharge is very easily affected by minute quantities of oxygen, the Swan spectrum may be due to (C). Although Smithells apparently made out a fairly good case in assigning the bands of the Swan spectrum to carbon monoxide, we believe that the importance of the difficulties raised by Konen should not be underestimated. As he points out, the presence of considerable quantities of salts in the solution in which the discharge takes place may not suffice to bring out metallic lines, and the cyanogen bands do not appear in weak solutions of ammonia. It may be, however, that a very small amount of oxygen would act energetically, and suffice to give rise to the Swan spectrum. But the last word on this subject has not been said, and it is to be hoped that further investigations will be made on the spectra of the electric discharge in liquids.<sup>44</sup>

There seems to be little difference of view regarding the origin of the cyanogen bands, which we have identified in the blue part of the spectrum. These bands also appear in the spectra of stars of Secchi's third type, as may be seen from an examination of the spectra reproduced in Plate VII.

Some discussion on the probable condition of carbon in stars of the third and fourth types, as well as in the Sun, may be found on p. 128.

#### IDENTIFICATION OF THE DARK LINES

The following table, supplemented by remarks on the several elements identified, summarizes the results of our study of the origin of the dark lines. The numbers in the column headed "Widened in Sun-Spots" are those given by Maunder in the *Greenwich Spectroscopic and Photographic Results*

<sup>41</sup>On the Spectra of Carbon Compounds. *Phil. Mag.*, 6th Ser., Vol. 1, 1891, p. 132.

<sup>42</sup>Ein Beitrag zur Kenntnis spectrokopischer Methoden," *Annalen der Physik*, Vol. IX, 1902, p. 742.

<sup>43</sup>On the Spectrum of Cyanogen. *Phil. Mag.*, 6th Ser., Vol. II, 1901, p. 326.

<sup>44</sup>The investigations by one of us on dark spectra in liquids were undertaken with different object in view.

for 1880. The amount of widening is in tenths of the normal width; the next column gives the number of spots in which the line was widened, out of eighteen observed. In the red region the amount of widening is taken from Cortie's papers in *Monthly Notices*, Vol. XLIX, p. 410. and Vol. LXII, p. 516.

We are fortunately able to include in the table the wave-lengths of lines in the spectrum of *a Orionis*, as measured by the late Professor Keeler on photographs taken with a three-prism spectrograph at the Allegheny Observatory. These were sent to us by Professor Keeler in manuscript for the purposes of this comparison. At the Conference of Astronomers held at the Yerkes Observatory in 1897 he described his photographs of third-type spectra as follows:

The series of slides included the spectra of *a Bootis*, *a Aurigae*, *a Tauri*, *a Orionis*, *a Scorpii*,  $\beta$  *Pegasi*, and *a Herculis*, in which may be observed a transition from the second to the third type. In stars like *a Orionis* the lines are essentially those of the solar spectrum, but the relative intensities are not the same, and the general aspect of the spectrum is different from that of the spectrum of the Sun. The dark bands characteristic of third-type stars are well shown, though they are not resolved into lines. The separate lines are doubtless far beyond the resolving power of the instrument. These bands are not always terminated by strong metallic lines, and the appearance noted by early observers was probably due to insufficient optical power. The strong lines are mostly those of iron—apparently the low-temperature lines. Their relatively greater strength in the star spectrum gives to some well-known solar groups (notably the *b* group) quite an unfamiliar aspect.

In *a Herculis* only a comparatively few of the strong metallic lines remain, while the bands are deep, and beautifully distinct. It is impossible to avoid the conclusion that the edges of the zones bordering on the dark bands are bright—much brighter, that is, than the average continuous spectrum—and that they are due to a real predominance of emission at the regions of the spectrum in which they occur. They are not merely the effect of absorption in adjoining regions. In the case of stars like *a Orionis*, of a less pure type, such a conclusion could not be safely drawn; yet the superior brightness of the spectrum at these places is obvious, and it can be traced even in second-type stars. May there not after all be bright regions in the solar spectrum, such as Draper supposed he had found in the places of the bright oxygen lines? And what is the relation between the dark bands in third-type stars and the bright zones which border on them?

It is an interesting fact that some of the bright lines, and also some of the dark lines in fourth-type spectra, similarly lie in close proximity to dark and bright zones.

COMPARISON WITH SUN-SPOTS AND WITH THIRD-TYPE STARS

FOURTH-TYPE STARS		PROBABLE ORIGIN	WIDENED IN SUN-SPOTS		REMARKS	TYPE III <i>a Orionis</i> —Keeler	
Wave- Length	Inten- sity		Amount of Widening	Number of Spots		Wave- Length	Intensity and Character
t.m.			No widened lines in this region		One-prism plate, wave-lengths uncertain by 1 t.m.	t.m.	
3933	10	<i>Ca</i> (K)				{ Strong lines See note 5	
3967	w	<i>Ca</i> (H)					
4004.4		<i>Fe, Ti</i>					
4018.3		<i>Fe, Mn</i>					
4034.8	1	<i>Fe, Mn</i>					
4058.2	3	<i>Fe, Co, Cr</i>					
4078.7		<i>Fe, Ti</i>					
4100.5	4	<i>H</i> ( <i>Hδ</i> )				See note 5	
4132.3		<i>Fe</i>					
4145.4	1	<i>Fe</i>					
4197.5							
4227.6	10	<i>Ca</i>				{ See note 1 Characteristic lines	
4254.4		<i>Cr</i>					
4274.0		<i>Fe, Cr, Ti</i>					
4282.8	1	<i>Ca, Fe</i>					
4289.0		<i>Ca, Cr, Ti</i>					
4304							
to							
4313						G group	
4325.9		<i>Fe</i>				See note 5	
4340.4	3	<i>H</i> ( <i>Hγ</i> )					
4354.2	2						
4363.4	2	<i>Cr</i>					

COMPARISON WITH SUN-SPOTS AND WITH THIRD-TYPE STARS *Continued*

TYPE IV STARS			WIDENED IN SUN-SPOTS		REMARKS	TYPE III a Orionis—Keeler	
Wave- Length	Inten- sity	POSSIBLE Chemicals	Wavelength	Number of Spots		Wave-Length	Intensity and Character
4384.7	6	Fe, V	No widened lines in this region		Carbon head	u.m.	
4389.0	2	V					
4392.0	2	Fe, Cr, V					
4395.0	6-7	V, Cr, Ti					
4398.0	1-2						
4401.0	4	Fe, V, Ni					
4403.3	4						
4405.1	3-4	Fr, Y			See note 4		
4408.5	3	Fe, V					
4410.9	1	Ni					
4412.4	2	V, Cr					
4415.3	3	Fe			See note 4		
4416.7	2	V					
4420.6	2	V, Zr					
4421.7	2-3	V, Ti					
4423.0	2	Fe, Ti, Y					
4425.9	2-3	Ca, Ti, V					
4427.7	2-3	Fe, Ti			See note 4		
4430.3	2	Fe, V					
4433.9	1	Fe, Ti					
4435.6	5	Ca, V					
4438.2	2-3	Fe, V					
4444.6	2-3	Fe, Ti, V					
4445.7	2	Fe					
4447.4	2	Fe, Mn					
4450.1	3	Ti, V					
4455.3	2	Ti, Ca, Mn					
4456.7	0-1	Fe, Ca					
4458.1	1	V, Ti, Mn					
4462.2	4	Fe, V, Mn			See note 4		
4465.4	2	Cr, Ti					
4466.9	2	Fe					
4468.9	1	V, Ti					
4471.7	1-2	Ti, Co					
4475.3	1	Ti					
4475.6	1	Cr					
4480.2	1-2	V, Fe					
4482.3	2-3	Fe					
4487.5	2						
4489.7	2-3	Fe, V, Cr					
4497.0	4	Ti, V, Cr					
4501.8	2-3	Ti, V			Carbon head		
4507.0	3						
4509.8	1-2	Ca					
4512.8	2	Ca, Ti					
4516.2	1						
4518.3	2	Ti					
4520.5	1	Fe					
4523.1	3-4	Ti			Important Ti group		
4527.4	2	Ca, Cr, Ti			See note 7		
4528.7	2	V, Fe					
4531.3	1-2	Fe, Cr					
4533.4	3	Ti					
4535.7	4-5	Cr, Ti					
4537.5	2-3	Cr					
4542.9	2	Fe, Cr					
4544.0	2	Cr, Ti					
4549.3	4	Fe, Ti			See note 7		
4552.8	7	Fe					
4553.8	7	Fe, Ti			Carbon head		
4560.3	3-4	Fe, Ti			Strongest Ca line in Bunsen flame		
4563.5	2-3	Cr, Ti			See note 7		
4565.8	2	Fe, Cr					

COMPARISON WITH SUN-SPOTS AND WITH THIRD-TYPE STARS—*Continued*

FOURTH-TYPE STARS		PROBABLE ORIGIN	WIDENED IN SUN-SPOTS		REMARKS	TYPE III <i>a. Orionis</i> —Keeler				
Wave- Length	Inten- sity		Amount of Widening	Number of Spots		Wave- Length	Intensity and Character			
t.m.			No widened lines in this region		Carbon head 4609	t.m.				
4571.8		Ti, Cr								
4575.4	2	Fe								
4577.5	1-2	V								
4580.5	1-2	Cr, Fe, V								
4582.6	1	Fe, Ca								
4584.7	2	Fe								
4586.4	2	V, Ca								
4587.4	2	Fe								
4591.2	2	Cr, V								
4594.2	2-3	V								
4597.4	1-2	Cr								
4600.8	2	Cr, Ni								
4602.9	2	Fe								
4606.8	7	Ni								
4607.5	4	Fe, Sr								
4610.3	1									
4611.4	2	Fe								
4613.9	2-3	Cr, Fe								
4616.4	3-4	Cr								
4619.5	3-4	Fe, Cr								
4622.9	2	Cr, Ti								
4628.7	1	Cr								
4629.7	4	Ti, Co								
4634.4	1									
4637.6	1	Fe								
4640.4	4-5	Fe, V, Ti								
4646.4	4	Cr								
4654.1	2-3	Fe								
4656.4	2	Ti								
4664.1	2	Cr								
4668.1	3	Fe, Ti, Ni								
4674.9	2-3	Fe, Ti								
4682.3	1-2	Ti								
4688.6	1	Fe								
4691.1	1	Ti, Fe								
4697.0	2	Cr								
4702.0	1	Ni								
4703.8	1	Ni								
4714.7	4	Ni								
4715.6		Ni								
4722.6	1-2	Ti, Zn								
4729.1	1	Fe								
4732.5	1	Ni								
4736.2	10	Fe								
4740.1	1									
4743.9	10	Fe? Ti								
4749.6	2									
4751.6	10	V								
4756.1	1	Fe, Cr								
4758.9	3-4	Ti								
4766.5	1-2	Mn								
4772.6	2	V, Fe								
4776.8	1-2	V								
4784.5	1-2									
4789.6	1-2	Fe, Cr								
4806.2	1									
4812.1	1	Ni, Ti								
4815.9	2									
4823.8	1-2	Fe, Mn								
4828.0	2									
4832.5	3-4	Fe								
4836.3	1									
4839.7	1	Fe								
4843.4	1-2	Fe								
4851.8	1	Ca, V								
						Dark band, continuous spectrum very faint				
						Bright zone; dark lines may be obscured or displaced by bright lines				
						Carbon head 4738 4744				
						Carbon head 4754 in 152° Schj.				
						Carbon head 4716				
						Carbon head 4716				

## COMPARISON WITH SUN SPOTS AND WITH THIRD-TYPE STARS—Continued

TYPE II		WIDENED IN SUN SPOTS		REMARKS	TYPE III a Orionis—Keeler		
Wave- Length	Inten- sity	Origin	Amount of Widening		Wave- Length	Intensity and Character	
m.					m.		
4855.5	1-2	Ni		Bright zone; dark lines may be obscured or displaced by bright line	4855.5		
4859.6	1	Fe			4861.5	About the same as Sun	
4861.3	10	H, H <sub>2</sub>			4864.4		
4865.1	2	V			4871.8	Same as Sun	
4867.7	1-2	Co	4		4875.6		
4871.5	2-3	V	6		4878.3	Strong in star	
4875.5	2	V	2		4882.0		
4878.3	1	Ca, Fe	5		4882.0	Sun?	
4881.6	3-4	V, Fe	6		4890.9		
4886.0	4	Fe, V	2		4891.6	Triple, as in Sun, but stronger	
4890.3	1-2	V			4900.3		
4901.1	2	Ti, V			4900.3	Same as Sun	
4906.4	3-4	V			4909.2		
4910.3	2	Fe	1	4	4920.7	Stronger than Sun	
4920.9	2-3	Fe	7	13	4920.7		
4925.2	1	Fe	2-3	6	4933.4	Same as Sun	
4934.1	2	Fe, Ba	5-6	13	4933.4		
4937.5					4934.3	Somewhat stronger than Sun	
4938.8					4937.5		
4939.9					4938.8	Stronger than Sun	
4945.6	1-2	Fe, Ni	1	3	4939.9		
4958.4	2				4956.0	Strong, not in Sun	
4981.8	3	Fe, Ti	6	10	4957.6		
					4982	Same as Sun	
					to		
					4984	Group, same as Sun	
					34 lines not in Type IV, in dark band		
5167.2	2	Fe, Mg, (b <sub>4</sub> )	5	15	5167.2		Carbon head 5164, see note 6
5173.4	5	Ti, Mg, (b <sub>2</sub> )	8-9	15	5169.2		
5183.8	3	Mg, b	5	15	5171.8	Bright space	
5189.2	1-2	Ca, Ti	5-6	7	5172.9		
5193.3	3-4	Fe, Ti, V	4-5	7	5183.8	See note 6	
5202.4	1	Fe	6	6	5191.6		
5205.8					5192.5	Same as Sun or a little stronger	
5210.1					5195		
5216.7	2	Fe		4	5204.8	Equal lines stronger than Sun	
5226.5	7	Cr, Fe, Ti	5-6	8	5206.2		
5234.0	3	V	4-5	3	5208.6	Weak in Sun	
5240.8	2		2	2	5210.6		
5247.4	3-4	Cr, Fe, Ti	4	2	5219.6	Not in Sun	
5251.5	3-4	Fe, Ti	3	2	5224		
5255.6	1-2	Cr, Fe	5	5	5227.2	Group, stronger than Sun	
5265.9	1	Ca, Cr	2-3	7	5247.7		
5270.4	4-5	Ca, Fe	5-6	12	5250.6	Strong, weak in Sun	
					5252.3		
					5254.1	Stronger than Sun	
					5264.1		
					5269.7	Stronger than Sun	
					5270.4		

## COMPARISON WITH SUN-SPOTS AND WITH THIRD-TYPE STARS—Continued

FOURTH-TYPE STARS		PROBABLE ORIGIN	WIDENED IN SUN-SPOTS		REMARKS	TYPE III <i>a Orionis</i> —Keeler	
Wave- Length	Inten- sity		Amount of Widening	Number of Spots		Wave-Length	Intensity and Character
t.m.						t.m.	
5283.6	1-2	Fe	4	5	Strong Cr group; see note 3	5297.0	Stronger than Sun
5298.2	3 4	Cr, Ti	5	5		5298.0	Same as Sun
5302.5	1-2	Fe	5	5			
5307.5	1	Fe	8	4			
5315.2	2-3	Fe					
5320.8	2 3	Fe					
5325.3	1	Co					
5329.0	3 4	Cr, Fe	6	3	Strong Cr group, note 3	5328.5	Somewhat stronger than Sun
5336.9	2	Ti	5	6			
5341.5	3	Fe, Mn	3-4	6		5341.2	Stronger than Sun
						5346.0	Stronger than Sun
5350.0	3	Ca, Fe	5	6		5348.5	A little stronger than Sun
5362.7	1	Fe, Co	2-3	3		5349	
5366.6	2						
5371.7	7-8	Fe, Cr	6	8	See note 4	5370	Same as Sun
5377.4	2-3	Fe, Mn	8	1		5371.6	Stronger than Sun
5384.7	1					5376.0	Not in Sun
5391.1	1		4	3			
5397.3	4	Fe, Ti	6	6		5397.2	Stronger than Sun
5406.4	1	Fe	8	6		5404	Weaker than Sun
5408.3	2-3					5406	Stronger than Sun
5410.4	2-3	Cr	5 6	5		5410.0	Stronger than Sun
5414.2	1-2					5411.1	Same as Sun
5420.2	3		1	2			
5425.1	1	Ni				5424.2	Same as Sun
5430.2	3	Fe	6	6		5426.5	Not in Sun
5434.3	1-2	Fe, V	4	5		5429.9	Stronger than Sun
5438.6	1-2	Fe, Ti				5433.0	Stronger than Sun
5447.8	7	Fe, Ti	6	5	See note 4	5434.7	Stronger than Sun
5456.8	2 3					5436	Same as Sun
5460.9	1 2					5445.2	Same as Sun
						5447.0	Stronger than Sun, edge of band
5467.3	1-2	Fe	1	1		5455.7	Stronger than Sun
5474.5	1-2	Fe	2	1			
5478.0	1-2	Ti	3-4	1		5461.0	Not in Sun
5483.0	1-2	Fe	3	1		5463.0	Weaker than Sun
5498.0	4	Fe	5-6	4			
5501.8	2	Fe	5	5	Carbon head 5505	5477	Same as Sun
5507.1	1	Fe				5497.6	Stronger than Sun
5512.4	2-3	Fe, Ti	5	5		5501.6	Stronger than Sun
5524.3	1-2	Fe				5507.0	Stronger than Sun
5525.4	1-2	Fe	6	1			
5528.6	1	Mg	5	6			
5533.9	1					5528.5?	Same as Sun
5539.5	7				Carbon head 5543		
5546.6	1-2	Fe					
5548.3	2	V					
5552.5	1						
5556.4	1-2						
5562.6	1	Fe	1	1			
5567.0	2		2	1			
5570.2	1	Fe					

Carbon flutings

Region here same as Sun

COMPARISON WITH SUN-SPOTS AND WITH THIRD-TYPE STARS — *continued*

WAVE-LENGTH		PROBABLE ORIGIN	WIDENED LINES IN SUN-SPOTS		REMARKS	TYPE III a. Obs. b. Keeler	
Å.	Inten.		Amount of Widening	Number of Stars		Wave-Length	Intensity and Character
t.m.						t.m.	
5573.7	1	<i>Fe</i>			Carbon head 5587	Carbon flutings	Region here same as Sun
5576.2							
5583.0	8						
5589.2	1	<i>Ca</i>	4	4			
5594.7	1-2	<i>Ca</i>	4	5			
5609.4	2					5598.5	Stronger than Sun
5615.7	1	<i>Fe</i>	4	4		5615.7	Same as Sun
5620.3	2-3			1	See Note 8	Bright zone, identifications uncertain	Stronger than Sun
5625.1	4	<i>V, Fe</i>	12	3			
5634.0	10	<i>Fe</i>	1	1	Carbon head 5638		
5641.2	1-2	<i>Ti</i>					
5649.1	1	<i>Fe</i>				5658.5	Stronger than Sun
5658.2	1-2	<i>V</i>	3	3		5663.0	Stronger than Sun
						5669	
5671.3	1-2	<i>V</i>					Strong, diffuse band not in Sun
5675.5	2	<i>Ti</i>	2	1			
5676.7	1-2					5682	
5689.7	1						
5708.3	2-3	<i>Fe, Ti</i>	1-2	3		5709.6	Stronger than Sun
5712.8	1-2		1	2		5712	Stronger than Sun
5721.3	2						
5731.6	3-4	<i>Fe, V</i>	3	2		5727.2	Stronger than Sun
5743.7	2	<i>V</i>				5732.0	Stronger than Sun
5749.4	2						
5751.7	1		1	2			
5762.5	2	<i>Fe, Ti</i>					
5771.0	2	<i>Fe</i>					
5778.0	1						
5784.8	3	<i>Fe</i>					
5789.6	1						
5798.1	1	<i>Fe</i>	1	1			
5822.9	2						
5848.5	1	<i>Fe</i>					
						5856	
						5860	
						5865	Region quite different from Sun
						5869	
						5875	
						5882	
5894.3	10	<i>Na (D)</i>	3		Widened lines obs. by Cortie	5890.2	Stronger than Sun
						5896.4	
						5914	Sun?
5921.0	1		5				
5945.0	1		5				
5975		<i>Sr</i>	10				
5999.1	1	<i>Sr</i>	10				
6008.5	3		5-6				
6119.0	2		6-7		Broad B line		
6190.3	2		4-5		Broad B line		
6269.6	10	<i>CaO, V</i>	10		Very strong. See note 1		
6357.6	3		2-3				
6435.3	8		6-7				
6488							
to							
6588							

1. *Carbonium* is well represented in these stars, the only contradictory evidence being the possible absence of the lines  $\lambda$  5290 and  $\lambda$  5295 (lines but slightly broadened in Sun-spots), which are probably obscured or displaced by emission spectrum. The line  $\lambda$  4229.0 is nearly as strong as H and K, suggesting a low temperature. The

strong flame lines at  $\lambda 6183$  and  $\lambda 6202$  fall on bright lines, but the very strong star line at  $\lambda 6270$  may include the flame line at  $\lambda 6265$ , attributed by Eder to  $\text{CaO}$ .

2. The group at  $\lambda 5270$  consists of two strong *Fe* lines and one strong *Ca* line. In the arc, with iron or carbon poles, the two iron lines are of equal intensity, but they are so different in the spark that the arc intensity (relative to the spark line as unity) is 0.9 for the line  $\lambda 5269.7$  and 5 for  $\lambda 5270.5$ . When titanium carbide (85 per cent. *Ti*) was placed on the lower carbon of the arc lamp, with four times the original exposure the line  $\lambda 5269.7$  kept its intensity, while  $\lambda 5270.5$  dropped to one-third. The wave-length of the center of the strong star line corresponds with the *Fe* line, which is strengthened in the arc, but weakened in the presence of *Ti*. This is also the wave-length of the *Ca* line.

3. *Chromium*.—The chromium lines in the region  $\lambda 4400$  to  $\lambda 4900$  are relatively weak in the arc and not represented by strong star lines. On the other hand, in the region  $\lambda 5100$  to  $\lambda 5700$  the most prominent chromium lines are relatively very strong in the arc, are usually widened in Sun-spots, and are represented by strong star lines. For example, the group  $\lambda 5204$  to  $\lambda 5208$  coincides very nearly with one of the most intense star lines outside the carbon flutings. The chromium line at  $\lambda 5225.1$  seems to form with the iron lines at  $\lambda 5227$ , the strong star line  $\lambda 5224.4$  to  $5228.6$ . The groups  $\lambda 5296$  to  $\lambda 5298$  and  $\lambda 5328$  to  $\lambda 5329$  coincide closely with strong star lines. The principal item of contradictory evidence is the lack of a star line to match the chromium group  $\lambda 5275$  to  $\lambda 5276$ , but it will be noticed that this group is but slightly widened in Sun-spots.

4. *Iron* is doubtless present in the star, but represented by comparatively weak lines. The principal cases in the blue region where the star lines are strong are  $\lambda\lambda 4405, 4415, 4427, 4462$ . In the yellow-green region numerous *Fe* lines, strong in the arc and broadened in Sun-spots, correspond with strong star lines; for example: associated with *Ti* at  $\lambda\lambda 5251, 5370, 5447$ ; with *Cr* and *Ti* at  $\lambda\lambda 5208, 5227$ ; and with *Ca* at  $\lambda 5270$ .

5. *Hydrogen*.—Of the hydrogen lines  $H\beta$  is present as a strong bright line in some plates of 280 *Schjellerup* and absent in others, but never appears as a dark line.  $H\gamma$  is present and  $H\delta$  prominent in the violet plates of 19 *Piscium* as dark lines.

6. *Magnesium*.—The *b* group is a prominent feature of the spectrum, and numerous other lines are present.

7. *Titanium*.—The group  $\lambda 4512$  to  $\lambda 4536$  gives striking evidence of the presence of titanium in the star. Of the eleven lines, ten are strong in the arc and represented in the star, while the line  $\lambda 4534.2$  alone is weak in the arc and absent in the star. For remarks on the behavior of the lines of this group in other stellar types, see p. 134. In the yellow region the titanium lines which are strong in the arc and much widened in Sun-spots are represented by strong star lines; for example, the line  $\lambda 5210.6$ , which according to Cortie<sup>25</sup> was the most widened line between *D* and *b* in the spot of May, 1901, is the strongest star line, and no line which is missing in the star has an intensity greater than 1 in the arc, or a widening greater than 4 in Sun-spots.

8. *Vanadium*.—The presence of vanadium seems well attested. The triplet at  $\lambda 5624$ – $5628$  is especially remarkable, as it is very strong in the arc and coincides closely with the strong star line whose limits in the best plates are  $\lambda 5623$ – $5628$ . In the vanadium are used the vanadium lines are weak in the region  $\lambda 5100$  to  $\lambda 5500$ , and strong in the region  $\lambda 5500$  to  $\lambda 5900$ . These strong lines are well represented in the star or obscured by the bright lines and zones. In general the vanadium lines which are missing in the star are weak in the arc.

No vanadium lines are identified as among those widened in Sun-spots by Maunder in the *Greenwich Results* for 1880. Photographs taken at the Yerkes Observatory show numerous vanadium lines widened, and it is now well known that vanadium lines are very characteristic of Sun-spots.

#### LINES WIDENED IN SUN-SPOTS

The agreement of the fourth-type with Sun-spot spectra is especially noticeable in the region  $\lambda 5160$ – $5500$ . The numerous lines in the region  $\lambda 5500$ – $5700$  which are widened in Sun-spots are masked in the stars by the carbon flutings, so that but few coincidences are found. Taking the data from the *Greenwich Results* for 1880, the forty-six lines which are most strongly and frequently widened in the spots are found to be the most prominent dark lines in the star. They are identified as follows:

<i>Fe</i>	22 lines	<i>Mg</i>	- - - -	3 lines
<i>Ti</i>	9 lines	<i>Ca</i>	- - - -	2 lines
<i>V</i>	5 lines	<i>Mn</i>	- - - -	1 line
<i>Cr</i>	4 lines			

<sup>25</sup> *Monthly Notices*, Vol. LXII, p. 516.

## TITANIUM

A comparison of Hasselberg's list in the region  $\lambda$  5186-5823 gives the following results:

Lines Found in the Stars		Lines Not Found in the Stars	
Widened in spots.....	23	Not widened.....	4
Mean number of spots.....	4	Widened.....	9
Mean intensity.....	5	Not widened.....	41
Mean intensity in star.....	3		

It is unfortunate that a similar comparison cannot be given for vanadium. Maunder does not give wave-length determinations, and his tables of vanadium lines were apparently inadequate for the identification of the fainter lines, which are frequently greatly widened in spots.

The following table contains Young's observations of lines widened in Sun-spots, compared with the fourth-type lines:

YOUNG'S LINES WIDENED IN SUN-SPOTS

Wave-Length in Angstroms Rowland's Scale	Amt. Wid.	Wave-Length and Character in Star (Dark line unless otherwise stated)	Wave-Length Reduced to Rowland's Scale	Amt. Wid.	Wave-Length and Character in Star (Dark line unless otherwise stated)
5191.5	2	B? lines	5424.7	3	25.1
5192.7	2	B? lines	5429.9	3	30.2
5198.9	3	B? lines	5434.1	4	34.3
5202.5	2	02.4	5447.0	4	46 to 49
5204.7	4	{ 04.6 to 11.5	5455.8	3	56.77, shifted by B at 53.8
5208.6	4		5487.9	3	B 86.5
5227.2	2	{ 24.4 to 28.6	5497.7	2	98.0
5230.0	2		5501.6	2	01.8
5233.1	2		5532.7	2	
5266.8	2		5572.8	2	{ Carbon fluting
5269.5	3	{ 69 to 71	5584.8	4	{ 83.9; strong, limits 81.9 to 85.9
5270.5	3		5586.6	3	
5328.1	{		5592.3	2	{ B zone
5328.3			5598.3	2	
5340.2	2		5602.9	2	
5341.2	2	41.5	5615.7	3	15.7
5343.5	2		5624.2	2	18.6 to 26.2
5370.1	4	{ 70.1 to 73.7	5662.7	4	{ B zone
5371.6	4		5706.3	4	
5397.2	5	{ 97.3 w	6065.7	3	59 w
5404.2	4	{ 06.4	6136.8	3	
5405.9	4		6191.7	2	90, narrow, between two B lines
5415.6	3	14.2	6358.9		

Young's list contains forty-six widened lines between  $\lambda$  5167 and  $\lambda$  6357. Of these twenty-five appear in the star (53 per cent.), while twelve are obscured by bright lines. In the region best photographed and most favorable for identification,  $\lambda$  5167 to  $\lambda$  5531, Young has thirty-three widened lines, of which twenty appear in the star (60 per cent.) and three are obscured by bright lines.

## IDENTIFICATION OF THE BRIGHT LINES

We have met with little success in attempting to identify the bright lines in fourth-type spectra. If numerous Sun-spots exist on these stars, it might be expected that violent eruptive phenomena would accompany them, and perhaps be recognizable spectroscopically. But a careful comparison with the chromospheric lines has given no evidence of genuine coincidences, except in the case of  $H\beta$ , which is bright in a few of the fourth-type stars. Comparisons with the spectra of nebulae, the aurora, various terrestrial gases, etc., have resulted similarly. Only in the case of the Wolf-Rayet stars is there any evidence of a common origin, and here it is too insecure to have much weight. The following table contains the results of a comparison of some of the Wolf-Rayet lines, as measured by Campbell,<sup>28</sup> with bright lines in fourth-type spectra.

<sup>28</sup> *Transactions of the American Astronomical Society*, Vol. XIII, 1901, p. 18.

In examining this evidence it should be borne in mind that the "very bright" (+ +) Wolf-Rayet lines  $\lambda\lambda$  4442, 4688, and the "bright" (+) lines  $\lambda\lambda$  4480, 4504, 4626, 4636, are certainly absent from fourth-type spectra. It will be noticed that these include Rydberg's principal series hydrogen line at  $\lambda$  4688, which is one of the most conspicuous and characteristic lines of the Wolf-Rayet stars. In some of them, however, it is inconspicuous, and in *SDM*,  $-11^{\circ}4593$  it is not observable visually, though shown on Campbell's photographs.  $\lambda$  4442 is very bright in many of the Wolf-Rayet stars, but in some of them it was neither seen nor photographed. From the range of Campbell's measures it seems quite improbable that the Wolf-Rayet line  $\lambda$  4466 can coincide with the fourth-type line  $\lambda$  4464.0. The Wolf-Rayet line  $\lambda$  4473 is presumably the helium line  $\lambda$  4471.7; hence it probably

FOURTH-TYPE STARS				WOLF-RAYET STARS—CAMPBELL			
Wave-Length		Inten- sity	No. Stars	Wave-Length		Inten- sity	No. Stars
Mean	Range			Mean	Range		
4464.0	63.8-64.1	4 5	7	4466	65-67	+	4
4473.6	73.6-73.6	4	2	4473	73-74	++	2 (Dark in 3)
4508.6	08.2-08.7	4	4	4509	04-10	+++	4 (Dark in 1)
4517.3	17.1-17.7	2	5	4517	15-18	+	4
4539.0	38.7-39.2	3	6	4541	34-44	++	21
4596.1	95.8-96.2	4	7	4596	92-98	....	5
4615.1	15.0-15.2	5	6	4615	14-16	....	4
4653.0	52.8-53.1	3	3	4652	50-54	++	14
4861.3	60.7-61.5	2 9	4	4862	...	++	21
5412.4	12.3-12.6	2	5	5412	10-16	++	21
5472.3	71.8-72.4	3 4	6	5472	69-74	+	13
5592.4	91.8-93.2	2 3	7	5593	90-96	++	15
5693.8	93.2-94.4	6	8	5693	90-95	+++	18
							Sharp in <i>DM</i> , $+30^{\circ}$ 3639, where wave-length is 5694.0

does not correspond with the fourth-type line  $\lambda$  4473.6. The Wolf-Rayet line  $\lambda$  4541 is undoubtedly a line of the second series of hydrogen; the mean wave-length of this line, as determined by Messrs. Frost and Adams on ten plates of four *Orion* stars, is 4542.0; hence it does not correspond with the fourth-type line  $\lambda$  4539.0. This fact, together with the absence of the  $\lambda$  4688 line of the principal series, makes it improbable that the agreement of the fourth-type line  $\lambda$  5412.46 with the second series hydrogen line  $\lambda$  5412 can have any meaning. On account of the well-known relationship between Wolf-Rayet and *Orion* type stars, it may be that the Wolf-Rayet lines  $\lambda\lambda$  4596, 4615, 4652 correspond with the oxygen and nitrogen lines  $\lambda\lambda$  4596.29 (O), 4614.0 (N), 4650.9 (O).<sup>7</sup> This would admit of the presence of the first of these lines in fourth-type stars, but would exclude the second and third. In this connection it should be added that oxygen and nitrogen lines (not present in Wolf-Rayet stars) may possibly coincide with fourth-type lines as follows:

OXYGEN AND NITROGEN		FOURTH-TYPE STARS		
Wave-Length (Frost and Adams)		Wave-Length	Intensity	No. Stars
4591.07 (O)		4590.3	3	3
4621.55 (N)		4621.5	5-6	5
4630.7 (N)		4631.2	4	5
4638.94 (O)		4638.9	4	8
4641.89 (O)		4642.1	4	6
4661.73 (O)		4660.6	2-3	3

In the first case the agreement is not satisfactory; in the last the line is so broad in the stars that it might include the oxygen line. The other four lines are conspicuous in most of the stars, and the close agreement of wave-lengths may perhaps be significant. It should be remarked, however, that many of the most prominent lines of oxygen and nitrogen do not appear among the fourth-type lines.

<sup>7</sup>Wave-lengths of Frost and Adams; identifications of Neovius.

With further reference to the Wolf-Rayet stars, it may be said that the generally broad and diffuse character of the lines, while it undoubtedly complicates the comparison by rendering the measures less accurate, may not preclude coincidence, in some cases at least, with the narrower fourth-type lines: for Campbell states<sup>3</sup> that in the Wolf-Rayet star *DM. +30-3639* the lines are better defined than in any of the other spectra, and that  $\lambda 5694$  is so sharp that it appears to be monochromatic. The close agreement of the wave-length of this line, determined from a long series of measures of this star made by Campbell, with that of the very strong and characteristic fourth-type line  $\lambda 5693.8$  suggests a common origin.

Since  $H\gamma$  and  $H\delta$  have been found with the two-foot reflector to be present as very prominent dark lines in the spectrum of 19 *Piscium*, while  $H\beta$  is present as a strong bright line in 280 *Schjellerup*, it becomes a matter of great interest to determine the character of the  $H\beta$  line in the spectra of other stars of the fourth type. From an examination of the catalogue of lines (see line No. 278, p. 100) it will be seen that  $H\beta$  appears to be absent from the spectra of 19 *Piscium*, 318 *Birmingham*, 78 *Schjellerup*, and 132 *Schjellerup*, while it is recorded as follows in the spectra of four stars:

Star	Intensity	Character	Wave-Length
280 <i>Schjellerup</i>	9	B	4861.4
78 <i>Schjellerup</i>	2	nn B	4861.5
115 <i>Schjellerup</i>	"Max"	B	4861.5
152 <i>Schjellerup</i>	1 2	n B??	4860.7

Hitherto the presence of dark  $H\delta$  and  $H\gamma$  lines in the spectra of fourth-type stars has been proved only in the case of 19 *Piscium*.<sup>4</sup> In the spectrum of this star  $H\beta$  is very faint or absent. Thus the condition of hydrogen in this star (and presumably in others of the fourth type) resembles its condition in the Wolf-Rayet stars, where the ultra-violet lines of this gas are dark, while some of the less refrangible lines are absent or bright.<sup>5</sup>

We would base no final conclusion on the data now available, but we believe that the slender evidence of similarity of spectra here presented, together with the collateral evidence afforded by the peculiarity of the hydrogen radiation in both types of stars, and their tendency to cluster in the Milky Way, should lead to a thorough investigation of the bright lines in the future. Some discussion of the bearing of these matters on stellar evolution and the classification of stellar spectra may be found elsewhere.<sup>6</sup>

The bright  $H\beta$  line in 280 *Schjellerup* seems to vary in intensity. The following photographs are available to test the question, and seem to leave no doubt regarding the fact, though the dispersion of the one-prism plates is insufficient to show minor changes:

INTENSITY OF THE BRIGHT  $H\beta$  LINE IN 280 *SCHJELLERUP*

Plate No.	Date	Intensity	Plate No.	Date	Intensity
6, 202	1898 6 3	Not shown	316	1899 10 18	10
234	9 7		360	12 21	Not shown
245	10 26	Not shown	364	12 28	" "
246	{ 10 31 }		367	12 29	" "
	{ 11 1 }	" "	370	1900 1 2	" "
274	1899 1 14	" "	385	2 15	" "
315	10 12	" "	388	2 25	" "

Pickering states that the  $H\beta$  line is of variable intensity in the spectrum of the star *A. G. C. 9181*.<sup>42</sup>

<sup>3</sup> See p. 141.

<sup>42</sup> See p. 130.

<sup>4</sup> Wolfson's paper presented his process of photographing the spectrum of the star *DM. +30-3639* as *DM. H. C.* Some time must have elapsed between the two, on the basis of the fact that the spectrum was recorded sixteen months after the discovery of this star.

<sup>5</sup> See p. 131.

<sup>6</sup> *Astrophysical Journal*, Vol. VII, 1898, p. 439.

## VARIABILITY OF FOURTH-TYPE STARS

There are 237 stars of this type included in Espin's *Revised Catalogue of the Stars of the IV Type*,<sup>43</sup> published in 1898. Of this number twenty-eight are recognized as variable in Chandler's *Third Catalogue*, and twenty more are included in the supplement issued in 1901 by the committee of the Astronomische Gesellschaft.<sup>44</sup> The total, forty-eight, is 20 per cent. of the whole number. The amount of variation, as given by the above catalogues, averages 2.4 magnitudes for forty-one stars. The range of variation is distributed as follows:

RANGE	NUMBER OF STARS	PERCENTAGE	
		Type IV	All Stars
Less than 1 mag. ....	1	2	1
1 mag. and less than 2. ....	13	32	18
2 mag. and less than 3. ....	12	25	6
3 mag. and less than 4. ....	7	17	9
4 mag. and less than 5. ....	5	12	50
5 mag. and greater. ....	3	7	18
	41		137

Column two gives the number and column three the percentage of stars having each range, and the last column gives corresponding percentages from Chandler's table<sup>45</sup> for all the variables well determined in his *First Catalogue*. In comparing the two columns of percentages, it should be remembered that Chandler's stars include the short-period variables, of small range, giving a maximum to the curve at a range between 1 and 2 magnitudes; but none of these short-period stars are of Type IV. Leaving these out of consideration, the maximum range for variables in general is about 4 or 5 magnitudes, but for Type IV the maximum range is about 2 magnitudes.

It now becomes interesting to consider the proportion of variables among stars of Types III and IV, as shown in the following table:

List	Number of Stars	Number of Variables	Percentage	Types
Espin <sup>46</sup> .....	237	48	20	IV
Dunér <sup>47</sup> .....	297	45	15	III
Frost-Scheiner <sup>48</sup> .....	1,217	125	10	III and IV

The above tables are necessarily incomplete, and it is probable that the number of variables in each class will be increased as observations are multiplied. But, as they stand, the tables are fairly comparable, and show that the tendency to variability is somewhat greater in stars of Type IV than in those of Type III.

## DISTRIBUTION OF FOURTH-TYPE STARS

The distribution of 242 stars of the fourth type with respect to the Milky Way was investigated by Mr. Parkhurst in 1898 and the results were presented at the Second Conference of Astronomers in August of that year. In 1899 Rev. T. E. Espin published in the *Astrophysical Journal* (Vol. X, p. 169) the results of a similar count of 224 stars, showing close agreement with Mr. Parkhurst's count. Both show that the distribution in north and south galactic latitude is quite similar, and that the stars are scattered quite evenly in the zone of latitudes greater than 30°. The following table gives the results found by Espin and Parkhurst, also the distribution of 9676 *Durchmusterung* stars of magni-

<sup>43</sup> *Monthly Notices*, Vol. LVIII (1898), p. 443.

<sup>44</sup> *Astronomical Journal*, Vol. XXII, p. 77.

<sup>45</sup> *Ibid.*, Vol. IX, p. 2.

<sup>46</sup> *Loc. cit.*, p. 444.

<sup>47</sup> "Sur les étoiles à spectres de la troisième classe," p. 15.

<sup>48</sup> *Astronomical Spectroscopy*, p. 402.

tudes 6.5 to 9.5, from Seeliger's count in the second Munich catalogue. The "Density" column gives the number per unit area (the sphere being taken as unity); the column "Condensation" gives for each zone the ratio of its density to the density in the zone  $>30^\circ$ .

Zone	NUMBER OF STARS		DENSITY		CONDENSATION		D.M. Stars
	Espin	Parkhurst	Espin	Parkhurst	Espin	Parkhurst	
0°-5°	123	92	708	1,060	11.4	18.3	2.7
5°-10°		46		532		9.2	2.6
10°-20°	43	58	256	345	4.0	6.0	2.1
20°-30°	27	17	171	108	3.0	1.9	1.5
$>30^\circ$	31	29	62	58	1.0	1.0	1.0
Total	224	242					

### PHYSICAL CONDITION OF FOURTH-TYPE STARS

The results described in the foregoing pages enable us to draw certain conclusions regarding the physical and chemical condition of fourth-type stars. It has long been assumed, perhaps on insufficient grounds, that the red color of these stars, indicating great general absorption in their atmospheres, might be considered as an index to a temperature lower than that of the Sun. Although we have been able, by giving a very prolonged exposure, to photograph the H and K lines in the spectrum of 19 *Piscium*, the faintness of this region in fourth-type spectra is so great that with ordinary exposures no trace of it is shown. With this marked increase of general absorption we also find evidence of increased selective absorption. This is most conspicuous in the case of the carbon bands<sup>50</sup> and the violet cyanogen band, which are wholly absent from the solar spectrum. The metallic lines are also in many cases much stronger than in the solar spectrum. These changes of intensity, for the most part, are such as would probably result from the cooling of a star like the Sun, especially if such cooling were accompanied by the development of extensive Sun-spots.

Let us now inquire more closely into the physical constitution of the fourth-type stars, at first with special reference to the level in their atmospheres at which the carbon absorption occurs. It is fortunately possible to answer this question with some definiteness, in view of certain observations of the carbon bands in the solar chromosphere made by one of us.<sup>51</sup> According to Lockyer's early view, the carbon flutings in the solar spectrum were due to the absorption of carbon vapor in the corona, at some distance above the chromosphere.<sup>52</sup> The large solar image given by the forty-inch Yerkes refractor permitted a test of this question to be made in 1897. With excellent atmospheric conditions and a very narrow tangential slit the numerous fine lines which constitute the green carbon fluting were seen to be bright at the very base of the chromosphere. As the least displacement of the instrument caused the lines to disappear, it was evident that the layer of carbon vapor is very thin, probably not exceeding a single second of arc in thickness. Subsequently, under exceptionally favorable conditions, seven lines in the yellow carbon fluting were seen as bright lines in the chromosphere. At the eclipse of January 22, 1898, the arcs corresponding to the heads of the cyanogen fluting at  $\lambda 3883$  were among the shortest photographed in the flash spectrum.<sup>53</sup>

The probability thus derived from solar observations that the carbon vapor in fourth-type stars lies in close contact with the photosphere is strengthened by the fact that several of the bright lines in fourth-type spectra are superposed upon the carbon flutings. It would thus appear that the unknown gases which produce these bright lines rise above the low-lying carbon vapor, just as hydrogen, helium,

<sup>50</sup> Throughout this discussion the band- or fluting-of the Swan spectrum are referred to for convenience as the "carbon" band. There is no doubt to some extent of a carbon, presumably, if this is the case, in the photosphere, see p. 126.

<sup>51</sup> GEORGE E. HALE, "On the Presence of Carbon in the Chromo-

sphere," *Astrophysical Journal*, Vol. VI (1897), p. 412; Vol. X (1899), p. 287.

<sup>52</sup> *Proc. Roy. Soc.*, Vol. XXVII, p. 308.

<sup>53</sup> LOCKYER, "Total Eclipse of the Sun, January 22, 1898—Observations at Viziadrag," *Phil. Trans.*, Vol. CXCXVII (1901), p. 203.

and calcium do in the solar chromosphere and prominences. We also find that many of the dark lines of iron and other elements are absent from fourth-type spectra, their places being covered by overlapping bright lines. Thus again, as in the case of the Sun, we have evidence that carbon in some form is associated with low-lying metallic vapors, above which rise the gases whose radiations reach us without reversal.

It is a curious fact, perhaps not without significance, that the cyanogen flutings beginning at  $\lambda 4609$  in fourth-type spectra do not appear to increase in strength from star to star, in harmony with the increase of intensity observed in the case of the carbon bands (see Plate VIII). This is the more remarkable when it is remembered that the cyanogen absorption in these stars is much stronger than in the case of the Sun, where these violet flutings appear to be entirely absent. For some reason the maximum intensity of these flutings seems to have been attained in so slightly developed a fourth-type star as 250 *Schjellerup*. In this connection the presence of these flutings in third-type stars, as indicated in Fig. 3, Plate VII, is of interest, particularly in view of the fact that the carbon (Swan spectrum) flutings seem to be absent from stars of the third type.

Further evidence of increased absorption, and possibly of decreased temperature, is afforded by the behavior of the metallic lines in fourth-type stars. Calcium offers an interesting case. It is well known that in the laboratory the line at  $\lambda 4227$  increases in relative strength as the temperature of the calcium vapor falls, and also, according to Huggins, as the density of the calcium vapor increases. In the Bunsen burner this is a conspicuous line, while H and K are absent. The great strength of this line in the spectrum of 19 *Piscium* (Fig. 2, Plate XI) should afford a valuable criterion as to the physical condition of these stars.<sup>53</sup> It should be noted in this connection, as the figure indicates, that this line is equally strong in the spectra of third-type stars. The very strong and broad line at  $\lambda 6270$  in the spectrum of 152 *Schjellerup* may possibly coincide with the strong line in the flame spectrum ascribed by Eder and Valenta to calcium oxide.

The tables of identifications contain more evidence of the same character. Perhaps the most interesting case of this kind is the variation of the relative intensities of the titanium lines in the group  $\lambda 4534-4536$ , referred to more particularly below in connection with the question of the classification of fourth-type stars.<sup>54</sup> The lines of this group are strongly developed in fourth-type spectra, with the exception of  $\lambda 4534.14$ , which is the only line of the group present in the spectra of the early *Orion* stars. This is an "enhanced" line, which in the spark spectrum is greatly reduced in intensity when the self-induction of the secondary circuit is increased. The changes in this group may be due to electrical rather than to thermal causes, but they at least harmonize with what might be expected to result from a reduction of temperature.

The possibility that spots like those on the Sun may form a characteristic feature of fourth-type stars is strongly suggested by the evidence which we have accumulated (p. 123). It is hardly necessary to say, however, that much more evidence in this direction is needed. In view of the ease with which Sun-spot spectra may be observed with instruments of moderate size, our knowledge of the widened lines is surprisingly meager. Much systematic work on spot spectra must therefore be done before the data desired for a thorough study of the question will become available. If the lines widened in Sun-spots are to be regarded as characteristic of fourth-type stars, they seem to be equally characteristic of stars of the third type. This fact will permit a rigorous test of the identification of the lines to be made, since several stars bright enough to be photographed with very high dispersion occur among the stars of the third type. It is hoped that the investigations now in progress at the Yerkes Observatory on the spectra of Sun-spots, and those which may soon be undertaken here with a cœlostat reflecting telescope and concave grating spectrograph on the spectra of a few of the brightest third-type stars, may permit a final decision to be reached regarding the presence of the

<sup>53</sup> It is hoped that experiments in progress at the Yerkes Observatory may permit the effects of temperature to be distinguished from those of density.

<sup>54</sup> See p. 131.

widened lines in the spectra of red stars. Sun-spots are presumably to be associated with a late rather than an early stage of solar development, and there is reason to suppose that they may grow more numerous as the Sun continues to cool. On *a priori* grounds, therefore, they might well be expected to be prominent features of red stars. The strong tendency of these stars to variability, which is even more pronounced in the case of fourth-type than in that of third-type stars, certainly does not lessen the probability that numerous Sun-spots are present.

The bright lines, of whose existence in fourth-type spectra we have given ample evidence, have offered difficulties of identification which we have hitherto been unable to overcome. It is a curious fact that the bright lines of the Wolf-Rayet stars, most of which have also proved impossible to identify, seem to agree in some cases with the bright lines of fourth-type spectra. From the detailed comparisons which are given elsewhere (p. 125) it will be seen that the evidence is by no means conclusive. The positions of the lines are not yet known with sufficient accuracy, and in any event the number of apparent coincidences is too small to have much meaning. In the course of this comparison, however, we could not fail to take into consideration the fact that the Wolf-Rayet and fourth-type stars possess in common a peculiarity which is shared by few other objects in the heavens, namely, the presence in their spectra of both bright and dark hydrogen lines.<sup>55</sup>

In a study of the spark discharge in liquids and in compressed gases<sup>56</sup> it has been found that as the conditions become more and more favorable to absorption—for example, as the pressure of the gas is increased—the reversals, which appear first in the ultra-violet, advance gradually into the visible spectrum. This dependence of selective absorption upon wave-length harmonizes completely with the earlier experiments of Living and Dewar, who obtained similar results with the electric furnace.<sup>57</sup>

In the Sun, although the entire series of hydrogen lines has been observed in the chromosphere, only the less refrangible members appear among the Fraunhofer lines. In this case we have a partial inversion of the phenomenon observed in Wolf-Rayet and fourth-type stars: the more refrangible members of the series are absent, while dark lines are present at the less refrangible end.

Kayser has proposed an explanation of such phenomena as a direct consequence of Kirchhoff's law. If the coefficient of absorption were identical for all spectral lines, the reversals should begin in the ultra-violet and advance toward the red. In the series lines of hydrogen, as represented in the Sun, the coefficient of absorption decreases so rapidly with the wave-length that the strong lines in the visible spectrum reverse first. The reversals should be strongest near the wave-length of maximum energy for the absorbing body.<sup>58</sup> As compared with the Sun, the Wolf-Rayet stars should therefore show a shift of the maximum of intensity in the hydrogen spectrum toward the violet.

It is fortunately possible to test this assumption, as Campbell has shown that the Wolf-Rayet star *D.M.* = 30 3659 has an extensive hydrogen atmosphere, the bright lines of which can be observed directly. Campbell, indeed, found that in this case *H $\alpha$*  is very faint, while *H $\gamma$*  is brighter and *H $\beta$*  is very bright indeed.

Langenbach has recently shown that the maximum of intensity in a line spectrum shifts toward the violet with increasing temperature, just as it does in the case of a continuous spectrum from a solid body. Thus with hydrogen an increase of current strength through the primary of the induction coil increased the intensity of the *H $\alpha$* , *H $\beta$* , and *H $\gamma$*  lines, but the increase was most rapid for the more refrangible of these lines. Similar results were found for lithium and helium.<sup>59</sup>

Langenbach concludes that his experiments indicate a very high temperature for the nebulae, where a similar shift of the maximum has been observed. Such a conclusion might perhaps apply to the Wolf-Rayet stars, but it would be out of harmony with what we know regarding stars of

<sup>55</sup> The existence of this fact in the classification of stellar spectra is discussed on p. 130.

<sup>56</sup> GEORGE E. HALE, "Note on the Spark Spectrum of Iron in Liquid and in Air at High Pressures," *Astrophysical Journal*, Vol. XV (1901), p. 10; GEORGE E. HALE, "SCOTT'S Absorption as a Function of Wave-length," *ibid.*, p. 237; GEORGE E. HALE AND N. A.

KENT, "Second Note on the Spark Spectrum of Iron in Liquids and Compressed Gases," *ibid.*, Vol. XVII (1902), p. 154.

<sup>57</sup> *Proc. Cambridge Phil. Soc.*, Vol. IV (1882), p. 276.

<sup>58</sup> *Astrophysical Journal*, Vol. XIV (1901), p. 303.

<sup>59</sup> *Annalen der Physik*, L., Vol. X, p. 789.

the fourth type. Pickering states that in a photograph of the spectrum of a meteor  $H\delta$  is the most intense of the hydrogen lines.<sup>60</sup> But would it be safe to conclude that the hydrogen in the meteor was hotter than the hydrogen in the Sun? In such a star as  $\gamma$  *Cassiopeiae*, where the temperature may be considerably higher than in the Sun,  $H\beta$  is more intense than any of the other lines. But in certain variable stars of long period, which are generally supposed to be cooler than the Sun,  $H\gamma$  is the strongest hydrogen line.<sup>61</sup>

In the case of the nebulae, meteor, and third-type variables, Thomson's observation of the spectrum of hydrogen in a vacuum tube, separated into two parts by an aluminium partition, may perhaps be significant. He found that  $H\alpha$  was brighter than  $H\beta$  at the positive pole, while at the negative pole the relative intensities of the two lines were reversed.<sup>61</sup> Although Kirchhoff's law could not be supposed to hold for a gas radiating in this way, a shift of the maximum thus produced might perhaps cause the effects observed in the case of the fourth-type stars. We believe that since much evidence favors the view that the fourth-type stars are cooler instead of hotter than the Sun, a further study of the whole subject must be made.<sup>62</sup>

#### CLASSIFICATION AND EVOLUTION OF FOURTH-TYPE STARS

Although we have investigated in detail the spectra of but eight stars, our collection of photographs comprises the spectra of the following stars of the fourth type: 7 *Schjellerup*, *D.M.*+57° 702, 27a *Schj.*, 41 *Schj.*, 51 *Schj.*, 72 *Schj.*, 74 *Schj.*, 78 *Schj.*, 115 *Schj.*, 318 *Birmingham*, 132 *Schj.*, 152 *Schj.*, 155b *Schj.*, 458 *Birm.*, 219 *Schj.*, 229 *Schj.*, 509 *Birm.*, 521 *Birm.*, 541 *Birm.*, 238 *Schj.*, 249a *Schj.*, 251 *Schj.*, 280 *Schj.*, 19 *Piscium*. All of these spectra have been used in a study of the classification and evolution of fourth-type stars. This inquiry divides naturally into two parts: (1) the development of these stars, as shown by changes in their spectra; (2) their relationship to other stars and their place in a general scheme of classification.

The criteria which we employed in arranging the stars in a series were the changes of the intensity of the carbon bands and of various groups of lines. The several series obtained independently by means of the different criteria in general agreed very well, though the peculiarities of certain lines sometimes changed the order somewhat in a few cases. The average series, based upon all the criteria, is illustrated in Plates VIII and IX. From these plates it will be seen that the spectra naturally fall into three divisions: (1), represented in the plates by the spectrum of 280 *Schj.*, includes also 541 *Birm.*; (2), represented in the plates by 19 *Pisc.*, 318 *Birm.*, 74 *Schj.*, 78 *Schj.*, 132 *Schj.*, and 115 *Schj.*, includes also 7 *Schj.*, 229 *Schj.*, 249a *Schj.*, 51 *Schj.*, 219 *Schj.*, 251 *Schj.*, 238 *Schj.*, 72 *Schj.*, and 458 *Birm.*; (3), represented in the plates by 152 *Schj.* and 155b *Schj.*, includes also 41 *Schj.*, 521 *Birm.*, 509 *Birm.*, 27a *Schj.*, and *D.M.*+57° 702. It will be seen that the second division contains a large proportion of the stars. Within this division the order of arrangement is somewhat uncertain, as the differences among the spectra are so inconspicuous that they are frequently offset by such effects as may arise from differences of slit-width, exposure time, development, etc. The approximate order in this division is indicated by the foregoing enumeration of the stars which comprise it. Many of these are so nearly alike that their relative places in the series cannot be certainly determined from available data.<sup>63</sup>

<sup>60</sup> *Harvard College Observatory Circular*, No. 20.

<sup>61</sup> *Proc. Roy. Soc.*, Vol. LVIII (1895), p. 255.

<sup>62</sup> We are informed by Professor Schuster that he has worked out a new explanation of the simultaneous presence of bright and dark lines in stellar spectra, which will soon be published. It is hoped that the solar work now in progress at the Yerkes Observatory may also throw some light on this question. We reserve a detailed discussion until certain experiments are completed.

<sup>63</sup> To indicate the character of some of the changes which occur in passing through the series of stars, the following lines are noted as peculiar to 132 *Schj.* and other stars in the third division:

1. *Blue region*.—The strong dark line  $\lambda$  4751.6, which shades off

toward the violet and appears like a fluting, is found only in 132 *Schj.* No high dispersion photographs were made for other stars of the third division.

2. *Yellow-green region*:

Bright line at  $\lambda$  5236.2, intensity 10; this line has intensity 6 in 115 *Schj.*, and is present, though less conspicuous, in the other stars.

Bright line at  $\lambda$  5508.3, intensity 5-6; this line has intensity 2-3 in 74, 78, and 132 *Schj.*

Bright line at  $\lambda$  5591.4, intensity 10. The most conspicuous bright line in the spectrum. It is near the brightest part of a carbon fluting; the other stars show a group of bright lines here whose combined intensity is very much less than that of the line in 132 *Schj.*

According to Dunér, the relative intensities of the carbon bands are not the same in all of these stars: in 19 *Piscium* the yellow band is much fainter than the other principal bands, while in 152 *Schjellerup* it is as strong as the blue band and nearly as strong as the green band. As our spectra were photographed in sections, we are not in a position to discuss this question, and we shall not undertake to do so. We can only say that our plates show nothing capricious about the behavior of the bands, as the stars occupy practically the same order in the series whether they be arranged with reference to the intensity of the blue or that of the yellow band. It therefore might appear that the absorption of carbon, as represented by either the blue or the yellow bands, increases gradually with the star's development. As Dunér's method of observation was better adapted than our own to show differences in the relative intensities of the bands, we would nevertheless attach greater weight to his opinion on this subject.

It will be noticed that the order of development in our series corresponds exactly with that given by Dunér in his memoir. In fact, so far as our results are comparable with those of Dunér, they generally tend to confirm them in all respects.

With few exceptions, spectroscopists have agreed that on account of the close resemblance between the two great classes of red stars, their spectra should be classed together. This was the view of Vogel when he prepared his system of classification and provided in the two subdivisions of his third class for the stars of Secchi's third and fourth types. Dunér, to whose valuable memoir we have had so many occasions to refer, considered that his observations went to confirm Vogel's classification, which he adopted without modification. Pechûle, on the contrary, held that the stars of Secchi's third and fourth types could not be considered as co-ordinate branches starting from the Sun, since no star was known to occupy a position intermediate between that of a fully developed fourth-type star and the Sun. As Pechûle's memoir is not accessible to us, we quote the following extract as given by Lockyer in *The Meteoritic Hypothesis* (p. 346):

M. Vogel a proposé une classification suivant les diverses phases de refroidissement indiquées par les spectres, dans laquelle il fait des types III et IV de Secchi deux subdivisions d'une même classe, IIIa et IIIb. Mais je trouve certaines difficultés négatives contre cette classification relativement au rôle qu'y joue le IIIb. En effet, il est admis que le IV type de Secchi se distingue nettement du III type, non seulement par la position et la quantité des zones obscures, mais aussi par le fait très-remarquable, que les principales de ces zones sont bien définies et brusquement interrompues du côté du violet dans le III type, du côté du rouge dans le IV. Or, si le IV type doit représenter une des phases de refroidissement, par lesquelles passent les étoiles, on peut faire deux hypothèses. La première est que le spectre du IV type soit co-ordonné au spectre du III type, de manière qu'il y ait des étoiles, qui passent de la phase représentée par le II type, à la phase représentée par le III type, et d'autres, qui passent directement du II type au IV. Mais cette hypothèse est inadmissible. Car on connaît des spectres intermédiaires entre le I et le II type, et entre le II et III; mais on ne connaît pas, à ce que je sache, des spectres du II type tendant au IV. Reste donc l'hypothèse, que la phase de refroidissement, représentée par le spectre du IV type, soit postérieure à la phase représentée par le III type, de manière que les spectres des étoiles passent du III au IV type. Si ce passage se fait peu à peu, il devrait y avoir des spectres intermédiaires entre le III et le IV type; mais quoique Secchi par exemple le 17 janvier 1868, ait déterminé le spectre de l'étoile 273 *Schell*, comme semblant intermédiaire entre le III et le IV type, il l'a plus tard reconnu du IV type, et l'existence des spectres de III-IV type n'est nullement prouvée. On pourrait objecter que les étoiles du IV type sont peu nombreuses et en général si petites que leurs spectres sont difficiles à voir, et que par conséquent il pourrait y avoir parmi les spectres quelques-uns, qui se rapprochent du III type. Mais je réponds à cette remarque, que les spectres du III-IV type, indiquant une phase moins refroidie, devraient au contraire en général appartenir à des étoiles plus grandes que celles ayant des spectres du IV type. Si on veut supposer que le passage du III au IV type se fasse subitement, ou par une catastrophe, pendant laquelle apparaissent des lignes brillantes, cette supposition même constituerait une différence physique bien plus distincte entre le III et le IV type qu'entre le II et le III; et le IV type représenterait une phase bien distincte, la dernière peut être avant l'extinction totale. Le rôle physique du IV type est donc encore si mystérieux, que j'ai cru pouvoir encore me conformer à l'exemple de d'Arrest, en suivant la classification formelle de Secchi.

Pechûle's objections were well answered by Dunér, who showed that in view of the comparatively small number of stars known to have spectra of Secchi's fourth type, it is not at all surprising that objects representing the transition from the solar stage have not been observed. As Dunér very justly remarks, it would be difficult to recognize stars in this transition stage without a much more thorough spectroscopic survey than has yet been made. Although 280 *Schjellerup*, which represents the earliest state of a fourth-type star that we have observed, contains many features characteristic of the fourth type, these might easily be overlooked in photographs taken with very low dispersion. As the spectra reproduced in Plates VIII and IX show, the carbon absorption bands in this star are relatively very feeble. In the yellow, the band is reduced to a single pair of heavy lines. Stars earlier in point of development would of course show even less marked evidence of carbon absorption, and would probably be classed as solar stars. 541 *Birmingham* (*D.M.* +35°3957), the star considered by Dunér to represent better than any other the transition stage, is shown by our photographs to have a spectrum practically identical with that of 280 *Schjellerup* (though we have no evidence as to the presence of the bright *Hβ* line). It may confidently be expected that when spectra of the solar type are better known, objects intermediate in development between 280 *Schjellerup* and the Sun will be discovered. This argument of Dunér's, which we can only confirm, disposes of Pechûle's principal objection to Vogel's classification. We shall have occasion farther on to refer more particularly to the close resemblance between the line spectra of the third and fourth types, as well as to other details which lead us to adopt the views of Vogel and Dunér.

According to the classification of stellar spectra developed by Lockyer in conjunction with his meteoritic hypothesis, stars of Secchi's third and fourth types are far removed from each other in point of development. The third type represents a swarm of meteorites in the first stage of transition from the nebulous to the stellar condition, while the fourth type represents the last stage in stellar life, immediately following the condition of the Sun.

So far as the fourth-type stars are concerned, it therefore appears that Lockyer adopts the view held by other investigators, and confirmed by the present research, namely, that they represent the last stage of stellar development. But we do not think that he has given sufficient reasons for separating fourth-type stars from those of the third type. In the first place, we are unable to understand how the spectra of third-type stars can be considered to resemble in any way the spectra of nebulae, or to be evolved from nebular spectra. So far as we are aware, no star showing a spectrum intermediate in character between that of a nebula and the spectrum of a third-type star has hitherto been detected. This seems to us a most serious objection to Lockyer's classification.

Furthermore, the results of the present investigation offer reasons for believing that the two great classes of red stars are closely related to each other, and that they are to be regarded as co-ordinate branches, each of which can be traced back to the Sun. The dark lines of the two types agree remarkably well (Plates X and XI). There is every reason to believe that if the bands were absent from the two types of spectra the line spectra would resemble each other very closely indeed—much more closely than either would resemble the spectrum of the Sun (Fig. 2, Plate XI). The chief distinction between the two types is thus confined to the bands and flutings, and even here we have a close resemblance in the case of cyanogen. The great strength of the  $\lambda$  4227 calcium line, and the probable presence as conspicuous features in both types of the lines greatly widened in Sun-spots, certainly tend to emphasize the relationship of the two classes of red stars. It would seem very important to secure further evidence regarding the question of widened lines, especially with reference to their exact identification in third-type spectra. If Sun-spots exist on these stars, they can hardly be regarded as slightly condensed meteor swarms, as required by the meteoritic hypothesis.

We may sum up the points of resemblance of third- and fourth-type stars as follows:

The stars resemble each other: (1) in their red color; (2) their remarkable tendency to variability; (3) the very close resemblance of the dark lines in their spectra; (4) the possibility that

the spectra of both may contain the lines which are widened in Sun-spots; (5) the similar physical conditions indicated by the character of their spectra; (6) the presence of bright lines in their spectra; (7) the presence in their spectra of dark flutings, of which the cyanogen flutings are common to both types; (8) the connection between both types of spectra and the spectra of solar stars.

Some of these points of resemblance are suggested rather than demonstrated by the results of the present research, and much work must be done in the future on the spectra of both these classes of stars. But we believe that the existing evidence is decidedly favorable to the views of Vogel and Dunen, and that stars of Secchi's third and fourth types should therefore be classed as co-ordinate branches, having their origin in solar stars.

Apart from the evidence afforded by the similarity of stars of the third and fourth types, certain other considerations bearing on the general question of classification should be presented here. It has already been shown that the Wolf-Rayet and fourth-type stars have three points in common: (1) their tendency to cluster in the Milky Way; (2) the presence in their spectra of bright lines, a few of which may be common to both types; (3) the presence in their spectra of both bright and dark hydrogen lines. If any organic relationship between these two classes of stars could be established, it would conflict seriously with current ideas regarding stellar evolution. The Wolf-Rayet stars, for many excellent reasons, are generally believed to be related to the *Orion* stars, and to precede stars like *Sirius* in point of development. We consider that the results of the present investigation do not oppose this view, but rather tend to strengthen it. In the first place, we are not prepared to say that the tendency of certain classes of stars to cluster in or near the Milky Way necessarily indicates any organic relationship between such objects. If it were assumed, for example, that the fourth-type stars are at immense distances from the Earth,<sup>64</sup> and that an absorbing medium, most dense near the poles of the Milky Way, exists in space, an apparent clustering of these stars toward the Milky Way would result. It would be impossible, of course, to account in this way for the fact that *all* of the Wolf-Rayet stars occur in the Milky Way (or in the Magellanic Clouds), but it does seem to follow that such a distribution of the fourth-type stars as we actually observe need not indicate any relationship with Wolf-Rayet stars.<sup>65</sup> Bright lines have been found in so many different types of spectra that they cannot be regarded as a safe basis for classification, and they are not employed for this purpose. Finally, as we have already remarked (p. 131), the variations in the relative intensities of the hydrogen lines in nebulae, Wolf-Rayet stars, third-type variables, and meteors are such as to permit no final conclusion to be drawn at present as to the physical condition implied by these phenomena. We therefore see no reason to believe that any important relationship connects the Wolf-Rayet and the fourth-type stars, though the bright lines and the physical condition of hydrogen in both should be made the subjects of further investigation.

The variations of the relative intensities of certain lines of titanium have an interesting bearing on the general classification of stellar spectra. The line  $\lambda$  4534.14, ascribed by Rowland to *Ti-Co*, is first seen in  $\beta$  and  $\gamma$  *Orionis* as an extremely faint and diffuse darkening on the continuous spectrum. The line grows steadily stronger in the following stars:  $\xi$  *Tauri*,  $\gamma$  *Corri* (Vogel's *Ib*),  $\epsilon$  *Ursae Majoris*,  $\alpha$  *Cephei*,  $\alpha$  *Canis Majoris* (Vogel's *Ia2*)—and reaches maximum intensity in a *Persei*, where it is narrow and sharp, and in  $\epsilon$  *Aurigae*, where it is broad. The line then decreases in intensity through the solar stars  $\gamma$  *Piscium* and  $\alpha$  *Boötis*, and in the third-type stars  $\alpha$  *Orionis* and  $\alpha$  *Tauri*, where it is the faintest line of the titanium group. In the fourth-type stars this line is the only one of the titanium group which is absent. In the spark spectrum of titanium, the line varies greatly

<sup>64</sup> Professor Huggins has very kindly looked up for us, in his excellent paper mentioned above, the number of fourth-type stars, and finds that the mean distance of the nearest proper motion is only about 0'01, while in other cases, which are not so well determined, the proper motion is apparently in no instance greater than 0'10, and for more than half the stars it is less than 0'05.

<sup>65</sup> The assumption that stars may differ in chemical composition, and that this may be related in some way to their distribution in space, must not be left out of account in an exhaustive discussion of stellar classification; but it need not be considered here.

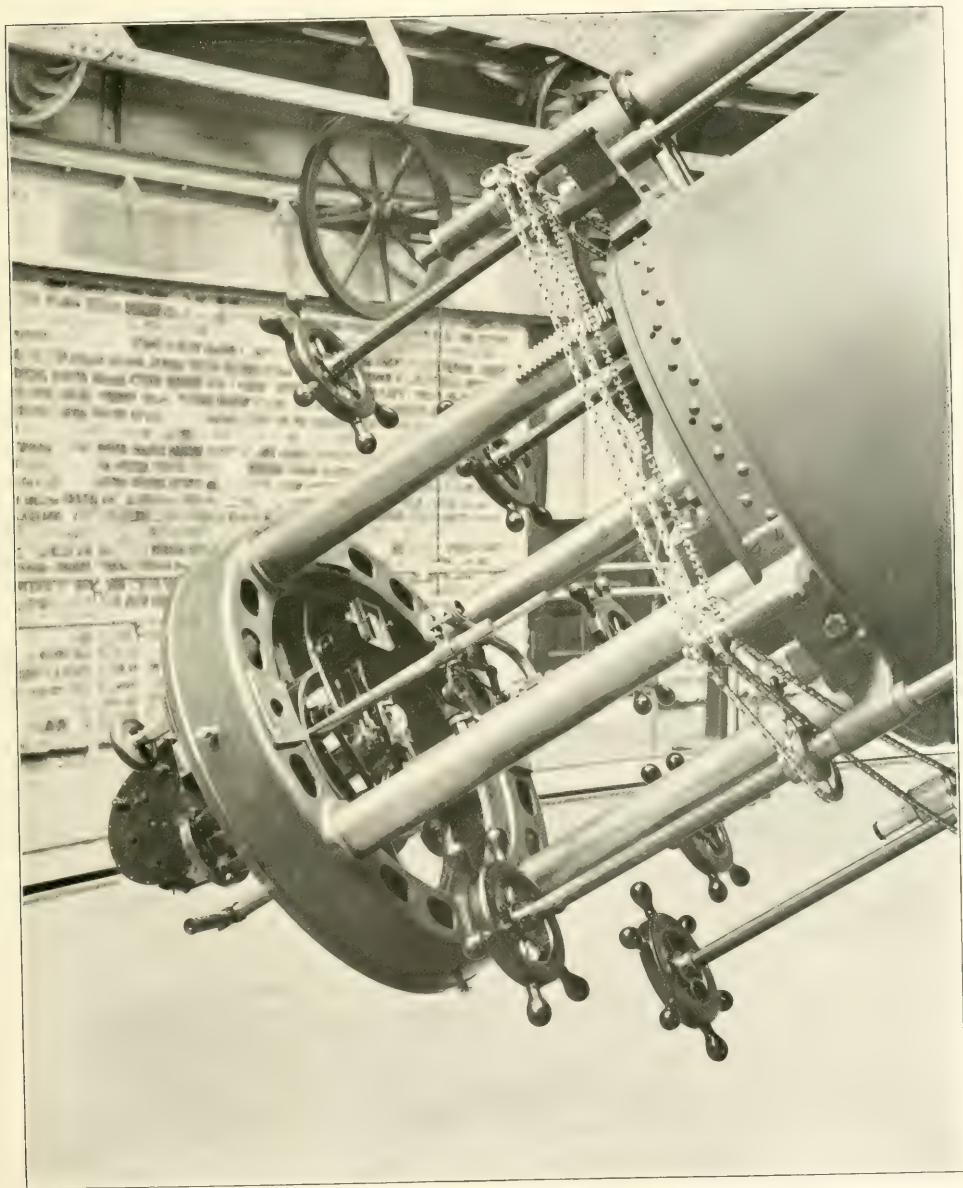
with change of self-induction in the secondary circuit, becoming fainter with increasing self-induction. It is stronger in the spark than in the arc.

The three lines of the group  $\lambda$  4538.8 – 4536.3, on the other hand, are absent or very faint in all of the stars preceding  $\gamma$  *Piscium* in the above list. They then appear as strong lines, and they are strongly represented in solar, third-type, and fourth-type stars. The changes of these lines are illustrated in Fig. 3, Plate XI. All of the photographs, except that of the fourth-type star 132 *Schjellerup*, were made with the Bruce spectrograph by Messrs. Frost and Adams, to whom we are indebted for some of the information given here.

#### SUMMARY OF RESULTS AND CONCLUSIONS

1. The spectra of stars of Secchi's fourth type contain a large number of bright and dark lines, in addition to the violet flutings of cyanogen and the flutings of the Swan spectrum.
2. The approximate radial velocities of eight stars range from + 5 km. to – 28 km.
3. Measures of the wave-lengths of 307 dark lines (average probable error of the mean, 0.07 m.) indicate that the following substances are represented: carbon (as cyanogen and in the elementary or combined state corresponding to the Swan spectrum), hydrogen, vanadium, calcium, magnesium, sodium, iron, chromium, titanium, nickel, manganese, and possibly two or three other substances.
4. The carbon and metallic vapors are very dense, and lie immediately above the photosphere.
5. Above these dense vapors of the reversing layer rise other vapors or gases, represented in the spectra by bright lines. The conditions are thus similar to those that exist on the Sun.
6. The bright lines, of which about 200 are present, seem to represent unknown gases, since none of them could be identified with certainty. A few of these lines may perhaps correspond with bright lines in the spectra of Wolf-Rayet stars.
7. The great strength of such lines as  $\lambda$  4227 of calcium, and the fact that arc and flame lines are strong, while spark lines are less prominent or missing, suggests, though it does not prove, that the temperature of the reversing layer may be lower than in the case of the Sun.
8. The fact that many lines widened in Sun-spots are represented by strong dark lines suggests that spots similar to those on the Sun may be numerous on fourth-type stars.
9. In the spectrum of 19 *Piscium*  $H\gamma$  and  $H\delta$  are present as dark lines, while  $H\beta$  is absent. In the spectrum of 280 *Schjellerup* and in some of the other stars  $H\beta$  appears as a bright line. Fourth-type spectra thus resemble spectra of the Wolf-Rayet type in showing the more refrangible hydrogen lines dark and the less refrangible ones bright or absent.
10. The bright  $H\beta$  line in the spectrum of 280 *Schjellerup* undergoes variations of intensity.
11. About 20 per cent. of the fourth-type stars are variable. The tendency to variability, therefore, seems to be even greater than in the case of stars of Secchi's third type.
12. The condensation of fourth-type stars in and near the Milky Way is very marked.
13. Stars of the third and fourth types resemble each other in color, tendency to variability, spectra, possible presence of Sun-spots, physical condition, and probable relationship to solar stars. They should therefore be classed together, as co-ordinate branches leading back to stars like the Sun.
14. Variations in the relative intensities of certain titanium lines indicate that fourth-type stars are probably very widely separated from Wolf-Rayet stars in point of development.
15. Fourth-type stars probably develop from stars like the Sun through loss of heat by radiation.





THREE-PRISM SPECTROGRAPH ATTACHED TO FORTY-INCH REFRACTOR



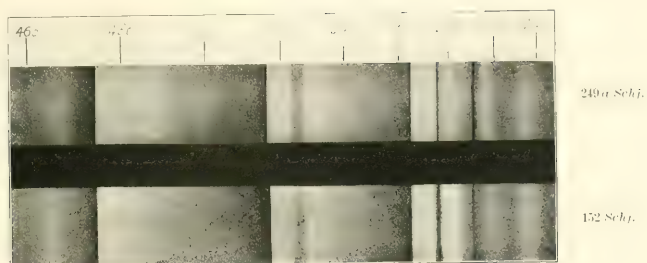


FIG. 1. SPECTRA OF FOURTH-TYPE STARS (VOGEL)

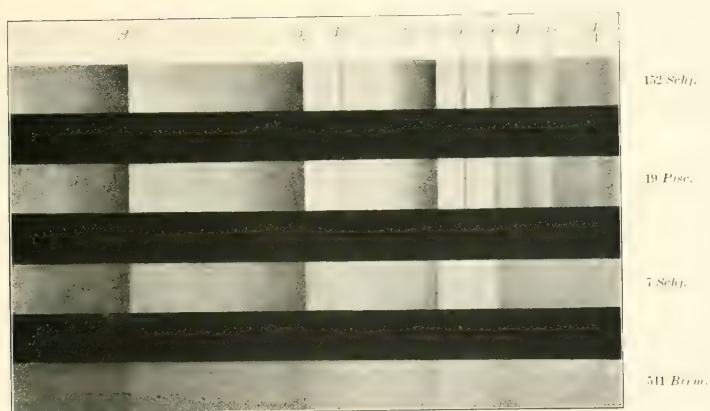


FIG. 2. SPECTRA OF FOURTH TYPE STARS (DUNÉR)

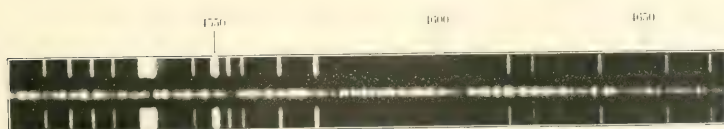


FIG. 3. BRIGHT LINES IN THE SPECTRUM OF 132 SCHJELLERUP



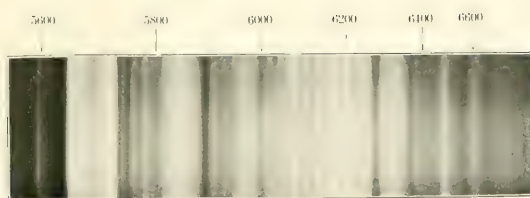


FIG. 1. RED END OF THE SPECTRUM OF 152 SCHILLERIT

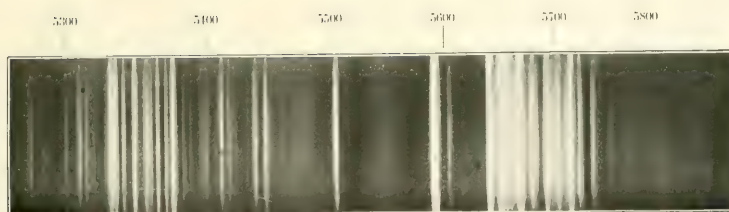


FIG. 2. BRIGHT LINES IN THE SPECTRUM OF 152 SCHIFFERUP

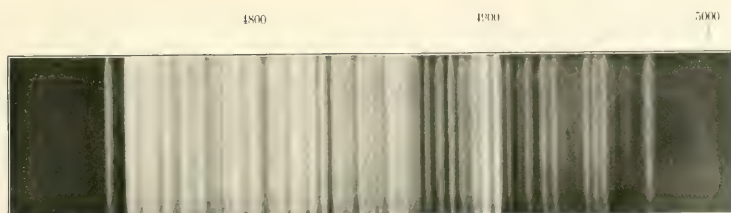


FIG. 3. BRIGHT LINES IN THE SPECTRUM OF 152 SCHWELLERUP



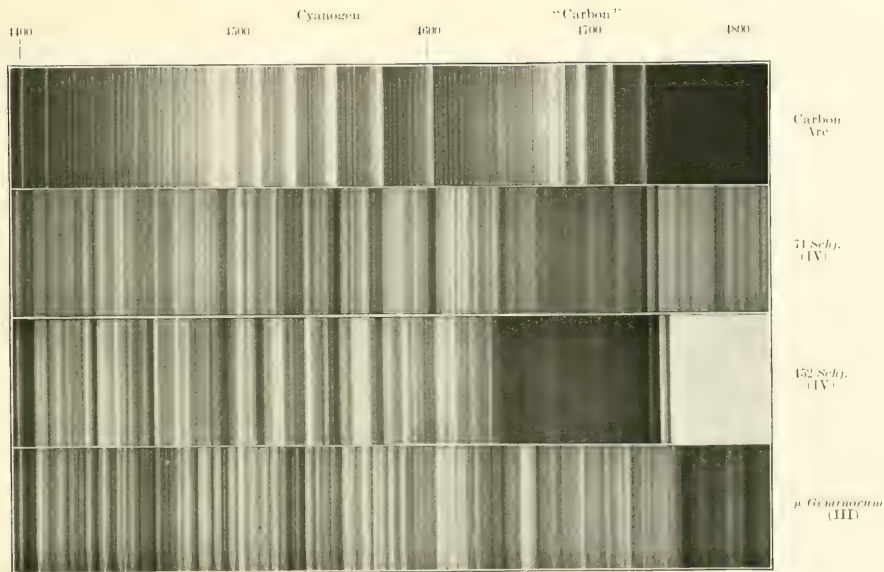


FIG. 1. BLUE CYANOGEN AND "CARBON" FLUTINGS

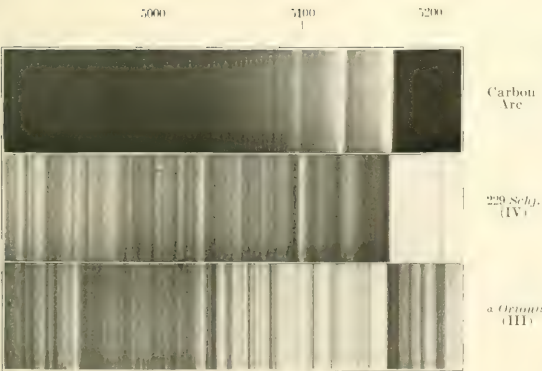


FIG. 2. GREEN "CARBON" FLUTING

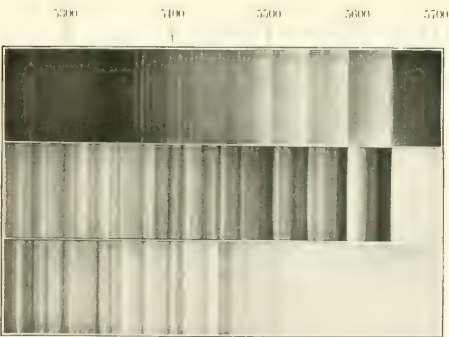
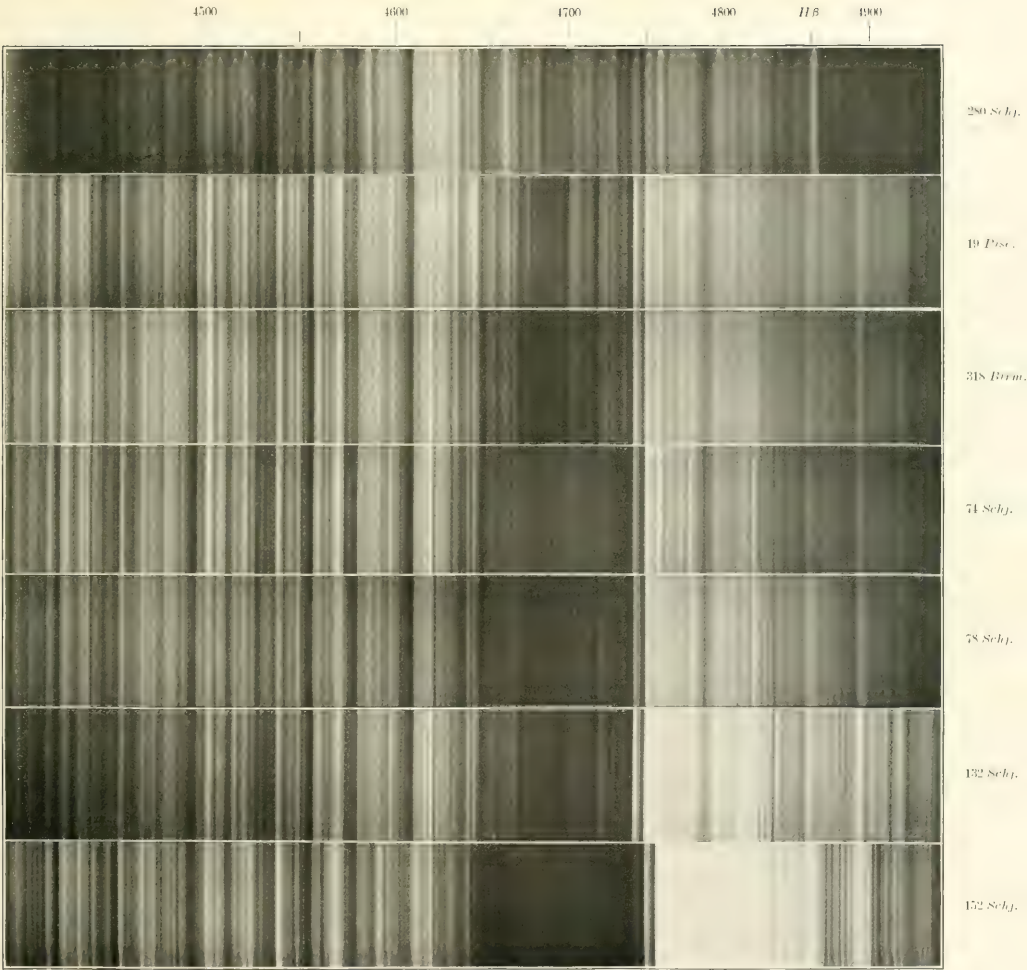


FIG. 3. YELLOW "CARBON" FLUTING

SPECTRUM OF CARBON ARC COMPARED WITH SPECTRA OF THIRD AND FOURTH TYPES





SPECTRA OF FOURTH-TYPE STARS (BLUE REGION)



5200 5300 5400 5500 5600 5700 5800



SPECTRA OF FOURTH-TYPE STARS (YELLOW AND GREEN REGION)



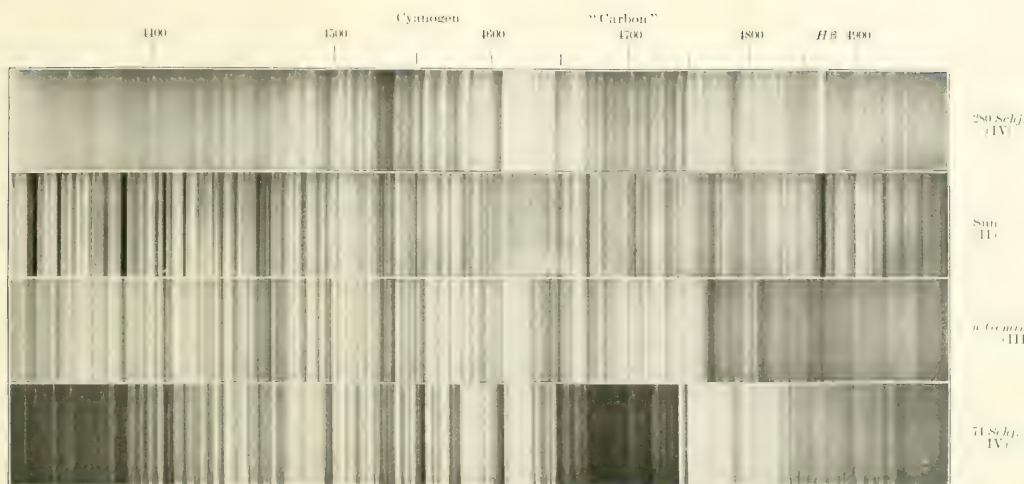


FIG. 1. BLUE REGION

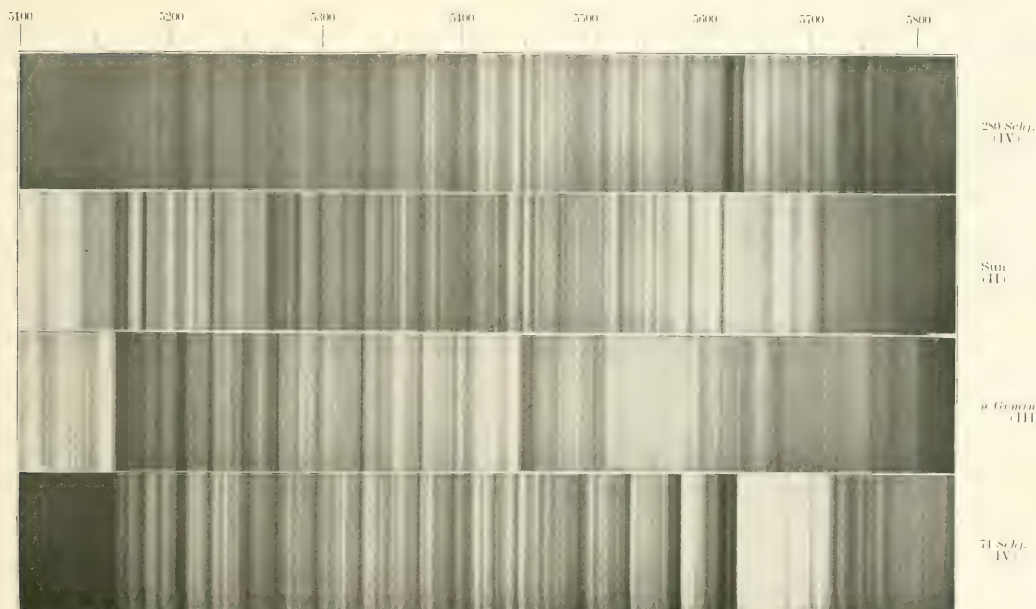


FIG. 2. GREEN AND YELLOW REGION

COMPARISON OF SPECTRA OF SECOND, THIRD, AND FOURTH TYPES



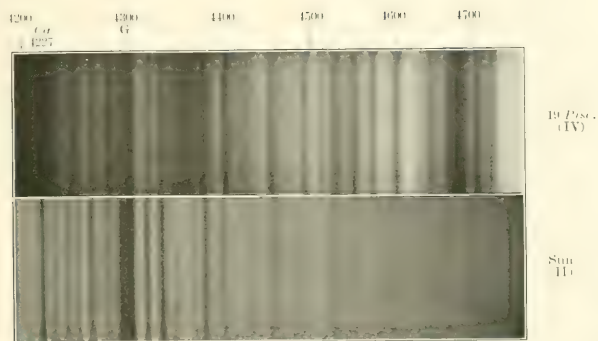


FIG. 1. SPECTRA OF SECOND AND FOURTH TYPES (BLUE REGION)

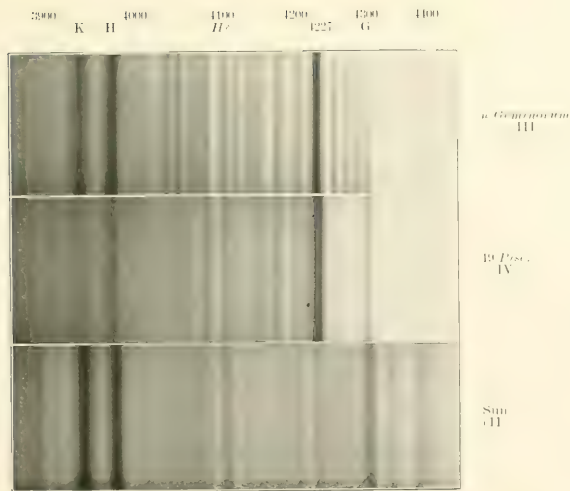


FIG. 2. SPECTRA OF SECOND, THIRD, AND FOURTH TYPES (VIOLET REGION)

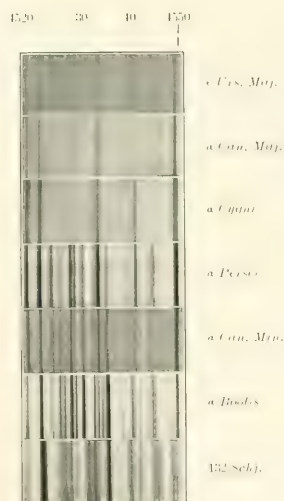


FIG. 3. TITANIUM LINES IN STELLAR SPECTRA



PHOTOGRAPHY WITH FORTY-INCH REFRACTOR AND  
TWO-FOOT REFLECTOR



# ASTRONOMICAL PHOTOGRAPHY WITH THE FORTY-INCH REFRACTOR AND THE TWO-FOOT REFLECTOR OF THE YERKES OBSERVATORY

G. W. RITCHEY

## I. PHOTOGRAPHY WITH THE FORTY-INCH REFRACTOR

IN the original design of the forty-inch refractor of the Yerkes Observatory no provision of any kind was made for direct photography. The objective is a visual one; there is no photographic corrector such as was provided for the great Lick refractor; and there is no powerful auxiliary telescope for guiding, such as are used in the cases of the "standard" photographic telescopes and of the very large photographic refractors at Potsdam and Meudon.

By the use of a method perfected by the writer in 1900, and described in the *Astrophysical Journal* for December of that year, the forty-inch visual refractor was made available for direct photography. The photographic attachment is simple and inexpensive; the entire apparatus cost less than \$100. A large number of photographs of star-clusters and of the Moon have been obtained, which are valuable on account of their great scale and fine definition.

The results described in the above-mentioned article were obtained with a small photographic attachment which allowed a field only three inches (about fourteen minutes of arc) square to be photographed at one time. A similar, but larger and more perfect, attachment, taking  $8 \times 10$ -inch plates, has since been constructed from my designs, for use with the great refractor. This allows a field of approximately  $36 \times 45$  minutes of arc to be photographed at one time, and of course includes the entire disk of the Moon. Many of the photographs described in the present article have been made with the larger apparatus.

The photographic attachment consists of a double-slide plate-carrier for guiding, on which is supported the plate-holder containing a yellow color-screen or ray-filter very nearly in contact with a yellow-sensitive (Cramer instantaneous isochromatic) plate.

The yellow screen freely transmits to the sensitive plate the sharp and intense yellow or visual image produced by the visual objective, and effectually excludes from the plate the blue and other wave-lengths of light which are not included in the visual image, and which would entirely destroy the sharpness of the photographs. Two very fine  $8 \times 10$ -inch yellow screens, one of slightly stronger tint than the other, were obtained after some experimenting. Each screen consists of two thin plates of glass, ground and polished approximately flat; one of these is coated with a film of collodion of a delicate yellow tint. After the collodion film is dry it is flowed with Canada balsam, and the second thin plate, which serves as a cover-glass, is put on. The two plates are bound together with adhesive tape. The screens are brilliantly transparent. When in use one of the screens is placed in the plate-holder directly in front of the yellow-sensitive plate. Screen and plate are separated only by the thickness of the binding tape around the edges of the former.

The double-slide plate-carrier, a device originally suggested by Dr. Common and described by him in *Monthly Notices*, Vol. XLIX, p. 297, permits very perfect guiding or following to be done, without the necessity of an auxiliary or guiding telescope. The large photographic attachment of the forty-inch refractor is illustrated in Plate XII. When in use, the apparatus is connected by four bolts to the large and massive ring, well shown in the illustration, to which all of the various attachments, spectroscopes, etc., with the exception of the micrometer, are in turn connected. This large ring can be racked in and out, and firmly clamped in any position, thus serving for focusing the various attachments. When the four connecting bolts are loosened, the entire attachment can be rotated in position-angle. Such rotation of the double-slide plate-carrier alone can be accomplished by means of the two

smaller rings (one of which can be rotated on the other) which directly support the double-slide. This rotation is convenient, and often necessary, in finding a suitable guiding star. The double-slide arrangement, one slide being at right angles to the other, is shown fairly well in the illustration. The two screws with large milled heads, by which the slides are moved in guiding, are well shown, one to the right of, the other below, the rectangular frame or box which carries the 8×10-inch plate-holder. The plate-holder is not shown.

To the upper side of the rectangular box is connected the small eyepiece by means of which the guiding star at the edge of the field being photographed is watched. A small diagonal prism, which can be seen inside of the rectangular box, overhangs the edge of the photographic plate, receives the light of the guiding star, and reflects it at right angles into the eyepiece. By this arrangement it is almost always possible to use a guiding star whose image is less than four inches distant from the center of the field being photographed. In the eyepiece are two fine cross-lines of spider-web, which are illuminated by faint red light from a very small incandescent lamp, the tubular socket for which is attached to the side of the eyepiece tube. To assist in finding a suitable guiding star, the eyepiece and its accessories are mounted on a slide which can be moved to any desired position on the upper side of the rectangular box, and firmly clamped there. The star which is to be used in guiding is brought to the intersection of the cross-lines in the eyepiece, and is kept there throughout the exposure of the sensitive plate, sometimes lasting four or five hours. The observer sits with his eye at the guiding eyepiece and his fingers on the two screws which move the slides, and thus he introduces any minute corrections of position which he sees are necessary.

The guiding eyepiece gives a magnifying power of about one thousand diameters. It is very seldom, indeed, that a star-image appears quiet in a very large telescope with such a magnifying power as this. Minute irregularities in the movement of the telescope in right ascension are almost always present, and render necessary continual watching and guiding. But larger and more troublesome are the irregular movements of the image which are due to the disturbed condition of the atmosphere. The effects of this lack of tranquillity and homogeneity of the atmosphere are of many kinds. Sometimes the image of the guiding star appears nearly quiet, but is very large and nebulous. At other times the star-image is a small brilliant point, but is dancing about so rapidly that many hundreds of corrections per minute would be necessary in order to follow it. After months of practice with the guiding apparatus the observer is able to introduce between one hundred and two hundred corrections per minute, when necessary. The work becomes almost automatic, but is extremely trying to the eyes when the tremors of the guiding star are rapid. The corrections can be made with great accuracy and almost instantaneously with the double-slide plate-carrier - with an effectiveness incomparably superior to that which can be attained by any other means now known.

The question arises whether the irregular movements of the images of the objects being photographed correspond exactly with those of the image of the guiding star. It would not be difficult to devise an apparatus by means of which the images of two or more stars in different parts of the field could be brought into apparent superposition, and thus this question could be answered. This has not been done, but the sharpness of the photographs obtained when guiding is done with great care is so superior to that resulting from less careful guiding that the conclusion is warranted that when the image of the guiding star is kept at the intersection of the cross-wires, the images of the objects being photographed are kept immovable on the photographic plate.

I have described the double-slide plate-carrier and its use somewhat in detail, because of the very great importance of this apparatus in long-exposure photography, especially with large telescopes. It has been asserted by prominent astronomers that such difficult objects as the dense star-clusters and the planets could never be satisfactorily photographed, because the very powerful telescopes which are necessary to show these objects satisfactorily are so large and heavy that they cannot be moved with the delicacy and quickness necessary to compensate for the constant irregular tremors always visible

with such great telescopes. Experience with the forty-inch refractor, with its enormous weight, the largest instrument thus far successfully used in direct photography, shows that the difficulty is completely solved by the use of the double-slide plate-carrier, in which the mass to be moved in making the necessary corrections is two or three pounds instead of ten or twenty tons. It is safe to assert that for the largest telescopes which could now be constructed, refractors or reflectors, the problem of efficient guiding during long exposures in direct photography is satisfactorily solved.

The photographs of star-clusters and the Moon obtained with the forty-inch refractor and its photographic attachment are certainly not inferior in separation or resolution to those obtained with the largest and best telescopes constructed especially for photography. In the best photographs of star-clusters obtained with the former instrument double stars of 1" distance are distinctly separated and measurable; and in the best lunar photographs craters one second of arc in diameter (corresponding to a little more than one mile) are shown as distinct rings. These results are due in part to the great size and focal length of the telescope, and in part to the effectiveness of the yellow screen in transmitting to the sensitive plate only those wave-lengths of light for which the color-curve of the objective is very nearly flat.

Even more surprising is the speed of the color-screen method. Although the ratio of focal length to aperture of the telescope is nearly as 19 to 1, fully timed photographs of the Moon are obtained with exposures varying from one-fourth of a second to one second. Stars which are at the visual limit of the instrument (approximately seventeenth magnitude) are photographed with two hours' exposure when atmospheric conditions are good, and with the most rapid yellow-sensitive plates. With five hours' exposure stars fully a magnitude fainter are photographed. This speed is possible, however, only after the observer has become expert in the use of the guiding apparatus, so that he introduces the necessary corrections instantly and almost automatically.

While this speed is greatly inferior to that of a well-made modern reflecting telescope with silvered glass mirrors, it is probable that the forty-inch visual refractor with the color-screen and the best yellow-sensitive plates now obtainable is nearly, if not quite, as rapid in photographing stars and the Moon as a forty-inch photographic refractor (one with its objective corrected for the blue, or so-called photographic, rays) would be. This opinion is based, in part, upon a comparison of photographs obtained with the largest photographic refractors and those obtained with the forty-inch visual instrument. The yellow-screen method utilizes the rays of light which are most freely transmitted by a large objective; it is a well-known fact that while only a small percentage of the yellow rays are lost by transmission through a large and necessarily thick objective, a very large percentage of the blue rays are thus lost; this is undoubtedly the reason why a yellow screen of delicate tint is sufficient to exclude the blue light from the photographic plate when this process is used with the forty-inch refractor.

The color-screen method and the double-slide plate-carrier are of course applicable for photography with all visual refractors, large or small, which are provided with clock-work for driving. By their use fainter stars can readily be photographed with any visual refractor than can be seen directly with the same instrument. In the work with the forty-inch refractor this is particularly noticeable in such cases as those of the fainter stars in the globular star-clusters. Stars which can be detected visually only with difficulty, and with fine atmospheric conditions, appear strong and distinct on the negatives obtained with moderately good atmospheric conditions.

In photographing the Moon at the focus of the forty-inch refractor (without amplification or enlargement of the image) the exposures required are so short that the double-slide plate-carrier is dispensed with, and a simpler apparatus is used to support the plate-holder. This apparatus is so arranged that an exposing shutter mounted in suitable guides can be moved across by hand, in front of the sensitive plate, in making the exposures. Diaphragms with apertures of various shapes, depending upon the phase of the Moon, are attached to the exposing shutter, and serve to equalize

the exposure time, the lunar terminator requiring a much longer exposure than that required for the bright limb. In making the photographs of the Moon, the instant of exposure is not chosen at random. An eyepiece with fine cross-wires is arranged in a tube with a diagonal prism at one end. This tube rests in a V-bearing, so that it can be instantly withdrawn without danger of jarring the telescope. The observer watches the lunar image by means of this eyepiece until an instant occurs when the definition is good and the image appears quiet with reference to the cross-wires; he then instantly withdraws the eyepiece tube (since this would overhang the photographic plate) and at the same time gives the signal to the assistant to move the exposing shutter across. I am indebted to Mr. F. L. Sullivan for able assistance in this and all other direct photographic work with the great refractor.

Plates XIII to XXI, which accompany this article, are from negatives obtained with the forty-inch refractor and its photographic attachment. The photograph of the lunar crater *Theophilus* and its surroundings (Plate XIII) is one of the best of the series, for it was made when atmospheric conditions were exceptionally fine, on the night of October 12, 1900. Much smaller details of the Moon's surface are shown here than have been photographed before. The exposure required in this case was less than one-half of a second. *Theophilus*, with its diameter of sixty-four miles, with its terraced wall or rampart rising three miles in vertical height above the crater-floor, with its great group of central mountains, and the enormous ridges and ravines of its outer slopes, is in many respects the most magnificent example of a lunar crater. The intricate system of radiating ridges of its outer slopes can be traced in the photograph for nearly one hundred miles from the crest of the rampart. Innumerable details are here reproduced with a minuteness and fidelity which are possible only by means of photography.

The illustration of *Mare Serenitatis* and *Mare Tranquillitatis* (Plate XIV) was obtained on the night of August 3, 1901, with an exposure of one second. The enlargement in this case is not nearly great enough to show the finer details visible in the negative, but was decided upon in order to include both plains on one plate. The surfaces of these plains are crossed by numerous ridges or wrinkles, large and small, which are beautifully shown in the original negatives, and on glass positives made from them, but which are difficult to reproduce, on account of the lack of sufficient contrast. The great serpentine ridge in *Mare Serenitatis* and the remarkable system of radiating ridges on *Mare Tranquillitatis* are among the most interesting features of the Moon's surface.

It was a fortunate coincidence, in the case of *Theophilus*, that exceptionally fine atmospheric conditions occurred when the crater was in the best position with reference to the terminator. No opportunity has occurred for photographing *Copernicus* under extremely fine conditions, although on account of the prominence of this superb object such an opportunity has been carefully watched for. The photograph of *Copernicus* shown in Plate XV is from a negative obtained on the night of November 20, 1901, with fairly good atmospheric conditions, and with an exposure of one-half of a second. While *Copernicus* is neither so large nor so deep as *Theophilus*, the system of radiating ridges and deep gullies constituting the outer slopes of the former is probably the most rugged and magnificent to be found on the Moon. The well-known rows of small craters at the west of *Copernicus*, as well as the much smaller rows to the south and northeast of the crater, are well shown in the photograph.

The illustration of *Mare Nubium* and *Bullialdus* (Plate XVI) is from the same large negative as that of *Copernicus*. The photograph shows well the remarkable details of the surface of this great plain—details strikingly different in character from those of *Mare Serenitatis* and *Mare Tranquillitatis*. The region of *Bullialdus* is in such a condition of illumination that it is particularly well seen. In the original negative the details of the outer slopes of *Bullialdus* are shown with remarkable sharpness; some idea of this can be gained from the half-tone illustration.

The photograph of *Clavius* and the surrounding region (Plate XVII) is also from the same negative as that of *Copernicus*. At the time when this photograph was taken the conditions of libration

and of illumination were unusually favorable for this region of the Moon's surface. *Clarius*, with its numerous included craters and other details; *Longomontanus* and *Wilhelm*, in which the details of the ramparts and of the crater-floors are unusually well shown; the extremely rough country north of *Wilhelm*; and the "metropolitan" crater *Tycho* conspicuous for its enormous depth, are among the most remarkable objects of this region.

The photograph of the great system of bright rays about *Tycho* (Plate XVIII) is from a negative obtained March 31, 1901. While the negative is not so extremely sharp as some others, a much greater enlargement than was possible here would be necessary to show well the astonishing richness of detail in this system of bright rays which is present in the original negative. The exposure time in this case was one-fourth of a second.

The half-tone process of reproduction is especially disappointing in the case of the star-clusters. Not only are hundreds of the fainter stars entirely lost, but the groups of bright stars which are sharply separated in the original negatives appear only as white patches in the half-tone illustrations. The writer expects to include, with the copies of this paper which are sent to observatories and individuals especially interested in astronomical photography, large prints, on photographic paper, of the subjects which have suffered most in reproduction by the half-tone process. The expense of these photographic prints has been met by a generous friend who is interested in the work.

The illustration of the Great Cluster in *Hercules*, *Messier 13* (Plate XIX), is from a negative obtained on the night of April 25, 1901, with the large photographic attachment and with an exposure of three hours. In the original negative the center of the cluster is well resolved. Lines and groups of stars of between the sixteenth and seventeenth magnitudes, and with distances down to  $1'$ , are well shown and distinctly separated. More than three thousand stars are shown on the negative, many of which are so faint that they are beyond the visual limit of the great telescope.

Smaller, but richer and more condensed, than *Messier 13* is that superb cluster *Messier 15 Pegasi* (Plate XX), although the effect of richness and condensation is to a large extent lost in the illustration, on account of the great scale and the loss of the fainter stars. The sharpest negative of this object was obtained on the night of October 3, 1900, with an exposure of three hours. On account of exceptionally fine atmospheric conditions during nearly one hour of this exposure, this is one of the best of the star-cluster photographs. A comparison of this photograph with others of the same object which have been published will demonstrate the advantages of telescopes of great focal length, and of an efficient guiding mechanism, in the photography of these difficult objects.

Two or more very sharp negatives of each of the dense globular clusters *Messier 2 Aquarii*, *Messier 3 Canum Venaticorum*, and *Messier 5 Libræ*, as well as of some of the larger and more open clusters, have also been obtained. It is believed that on account of the great scale and excellent definition of these photographs they will prove extremely valuable for comparison with photographs obtained several years later, in the search for change and rotation in these clusters.

The photograph of the central parts of the great nebula in *Orion* (Plate XXI) was obtained with the forty-inch refractor with an exposure of three hours, January 20, 1901. The night was extremely transparent, but atmospheric conditions were not fine in other respects, so that the star-images appear large. The yellow-screen process is not well adapted for the photography of nebulae, since the light of these objects consists almost exclusively of green and blue rays. The blue rays are entirely excluded by the yellow screen, and the green rays, which are imperfectly transmitted (and by which the nebula is photographed) are not brought to a focus in the same plane in which the star-images are in best focus. But similar difficulties in regard to focus are encountered even with the best photographic refractors.

It is only with the reflecting telescope that the intolerable difficulties due to imperfect achromatism are entirely absent. In the present case the focal setting used was that which is best for the stars; consequently the details of the nebula are slightly out of focus. The photograph is introduced

in order to call attention to the difficulties just described, and also because, on account of the great scale, the details of the central parts of this celebrated nebula are shown better than in any other photographs of this object with which the writer is acquainted.

## II. PHOTOGRAPHY WITH THE TWO-FOOT REFLECTOR

The two-foot reflector of this observatory (Plate XXII) was described somewhat at length in my article in the *Astrophysical Journal* for November, 1901; a detailed description of the instrument is therefore not necessary here; the following statements may, however, be made in regard to it:

The large mirror has a clear aperture of  $23\frac{1}{2}$  inches and a focal length of 93 inches. The instrument is used as a Newtonian for direct photography, and also as a Cassegrain for direct photography and spectroscopic work; the convex Cassegrain mirror is 5 inches in diameter and gives an equivalent focal length of 38 feet; as there is no central hole through the large mirror, three reflections are necessary when the convex mirror is used. The mounting is massive and rigid. The tube consists of a skeleton framework of steel tubes and cast-aluminum rings. The driving-clock and clock-connections are unusually large and strong. A small double-slide plate-carrier which allows a field three inches square to be photographed, is used for guiding in direct photography at either the primary or secondary focus. All of the mechanical parts of the instrument were made in the instrument shop of the observatory; the optical parts were made by the writer.

Special attention was given to the perfection of the optical parts; to the stability of the mirror supports and the rigidity of the skeleton tube, in order that the adjustment or collimation of the optical parts might remain perfect during long exposures; and to the refinement of the driving mechanism and the guiding apparatus. In nearly all respects the same degree of care and refinement was used in the making of this instrument as is given in the case of the best modern refractors.

The performance of the instrument in direct photography at the primary focus is highly satisfactory. As stated in my previous article, "the combination of (1) stability of position of the mirrors, (2) rigidity of skeleton tube, (3) smoothness of clock-driving, and (4) accuracy of guiding made possible by the use of the double-slide plate-carrier, is so effective that when atmospheric conditions are good the image of a guiding star in the eyepiece does not wander so much as one one-hundredth of a millimeter during an exposure of three or four hours. The accuracy with which the star-images are kept immovable on the photographic plate is nearly as great, as is shown by the photographs. In the best negative with four hours' exposure the images of the smaller stars near the center of the field are about  $2''$  in diameter. Double stars of  $2.5$  distance are sharply separated, and those of  $2''$  distance, corresponding to about  $0.02$  mm. on the photographic plate, are measurable."

"No greater mistake could be made than to suppose that the finest atmospheric conditions are unnecessary to secure the best results in photographing the nebulae. With such conditions the photographs show that these objects are not diffused hazy masses, but that their structure is generally most complicated, often consisting of exquisitely fine filaments and delicate narrow rifts. In these photographs the intersections of such filaments and rifts can be set upon, in the measuring machine, with almost the same degree of accuracy that is possible in the case of star-images. Changes of form in the nebulae, if such occur, could be detected with certainty by means of such photographs."

A large refracting telescope, whether visual or photographic, is not an efficient and economical instrument for photography, either direct or with the spectroscope, when compared with a modern reflector. The two-foot reflector, with its focal length of ninety-three inches and with its aperture reduced to fifteen inches, photographs seventeenth-magnitude stars with two hours' exposure. This speed is equal to that of the forty-inch refractor with the color-screen, with the finest atmospheric conditions, *i. e.* when the guiding star appears in the eyepiece as an extremely small point, and when irregular movements of the guiding star are so slow and so small that they can be readily followed. It is probable that this speed is nearly, if not quite, equal to that of the largest photographic refrac-

tors in use. When the full aperture is used, the two-foot reflector photographs seventeenth-magnitude stars with forty minutes' exposure.

That the great difference in speed between refractors and reflectors in photographing stars is not due largely to difference of angular aperture is amply proved by the few results which have been obtained with the two-foot reflector when used as a Cassegrain, *i. e.*, with the addition of the convex mirror, which gives an equivalent focal length of thirty-eight feet. Photographs made for comparison *when atmospheric conditions are good* (so that star-images appear as very small points even at the secondary focus), show that with this great equivalent focal length stars are photographed very nearly as rapidly as at the primary focus; the difference in speed is so slight that it is readily accounted for by the assumption that about 10 per cent. of the light is lost by the additional reflection at the convex mirror. I am aware that this result is apparently at variance with theories in regard to the effect of focal length (when the aperture remains constant) upon the size and intensity of the diffraction disks of star-images, and consequently upon the speed with which such images are photographed.

The great superiority of the reflecting telescope in photography is unquestionably due, primarily, to its perfect achromatism. The importance of this has of course been recognized for many years, but I think that the *degree* of the importance, *in photography*, of perfect achromatism has not been appreciated — that the effect of this achromatism in giving great speed as well as great sharpness has not been fully recognized. Hardly less important is the fact that in the case of large instruments much less light is lost, of the wave-lengths which are most effective in photography, by absorption at the silver surfaces of a reflector than by absorption and reflection in an objective.

In the case of the refractor the difficulties due to imperfect achromatism, as well as the percentage of light lost in transmission, increase rapidly with increase of size of the objective. In the case of the reflector, however, a large instrument is as perfectly achromatic as a small one, and the percentage of light lost does not increase with increase of aperture. But the reflecting telescope has not been developed to the state of refinement which has been attained in the case of the refractor. This is probably due, to a large extent, to the fact that the difficulties and peculiarities of the reflector have not been thoroughly understood; at any rate, it is certain that these difficulties have not, in the past, been successfully met. It is almost superfluous to state that the great reflectors of the past, without exception, have been in many respects extremely crude instruments; in all cases without the great rigidity and stability of construction which are absolutely essential to the successful performance of a reflector; and in all cases without the refinement of workmanship, in both optical and mechanical parts, which are attained in the great modern refractors. In saying this I certainly intend no criticism of the able and skilful men who have been the pioneers in the development of the reflecting telescope, and who have contributed so much to both the methods and the results of astronomical observation.

It is safe to assert that the peculiar difficulties of the reflecting telescope are now thoroughly understood, and that all difficulties which relate to its mechanical and optical construction have been successfully solved.

As a result of the improvements and developments in glass-making, in optical work, and in the methods and materials of modern mechanical construction; and as a result, no less, of the experience of those who have both made reflecting telescopes of moderate size and used them successfully in astronomical photography, there can be no doubt whatever that a great reflecting telescope of five or eight feet aperture could now be constructed with all of the refinement of the two-foot reflector or the forty-inch refractor.

The speed of the reflector in the photography of nebulae is of course due largely to its great angular aperture. All of the reflector photographs which accompany this article, with the exception of that of *Messier 51*, were made with the aperture of the 23½-inch mirror reduced to 18 inches, in order that good definition might be secured over a larger field than is well covered when the full aperture is used. The ratio of focal length to aperture was therefore as 5½ to 1. These photographs

show what can be done with a reflecting telescope of very moderate size (aperture 18 inches, focal length 93 inches) when sufficient care is given to the perfection of the mirrors and mounting, and when an effective method of guiding is employed.

The photograph of the great nebula in *Orion* (Plate XXIII) was obtained with an exposure of one hour. Even with this short exposure faint extensions of the nebula and a great amount of delicate structure in the moderately bright parts are shown, which cannot be detected visually with either the two-foot reflector or the 40-inch refractor. A comparison of this photograph with that of the central part of the same nebula obtained with the forty-inch refractor (Plate XXI), and also with other published photographs of this object obtained with photographic refractors, gives some idea of the great efficiency of a well-made modern reflector of large angular aperture in such work.

The photograph of the great nebula in *Andromeda* (Plate XXIV) was obtained with an exposure of four hours, although one hour's exposure, or less, is sufficient to show the general characteristics of the object well. This is one of the most magnificent examples of a spiral nebula to be found in the heavens, yet its spiral character was never suspected from visual observations. In the original negative the spiral structure is visible almost to the center of the nebula, and the stellar nucleus is distinctly seen. Sharply defined narrow rifts and dark holes near the center are shown on all of the negatives of this object; no trace of these can be detected visually with any telescope.

The photograph of the spiral nebula *Messier 33 Trianguli* (Plate XXV) was obtained with an exposure of four hours. This nebula is very large and very faint; the spiral character of its central parts was discovered by Lord Rosse; by far the greater part of the complicated structure shown in the photograph is too faint to be detected visually. While differing greatly in general appearance from the great *Andromeda* nebula, *Messier 33* resembles the latter in several striking characteristics; in the presence of dark rifts and holes in and near the bright central parts, and in the tendency of its outer branches to break up into stars. The central parts of this object appear decidedly nebulous; the outer parts consist of very faint nebulosity and of numerous curved streams or wisps of nebulous stars; hundreds of these star-like condensations are so distinctly shown on the original negative that they may be well seen even in the half-tone reproduction. There can be no doubt of the physical connection between the nebulosity and the streams of minute stars; this object therefore affords what is apparently a most striking example of a spiral nebula condensing into stars.

The illustration of the nebulosities in the *Pleiades* (Plate XXVI) is from a negative obtained with an exposure of three and one-half hours. This photograph is extremely difficult to reproduce properly, on account of the great difference in brightness between the bright stars and the faint masses of nebulosity. Some idea of the intricate filamentous structure of these masses may be gained from the half-tone plate. In the original negative, from which I hope a more satisfactory reproduction may yet be secured, the entire field, nearly two degrees square, is covered with a network of filaments, of which those in the southwest part of the photograph, and apparently connected with the great curved mass of streamers about *Merope*, are the most conspicuous. Only the brighter filaments of this vast network are shown in the reproduction.

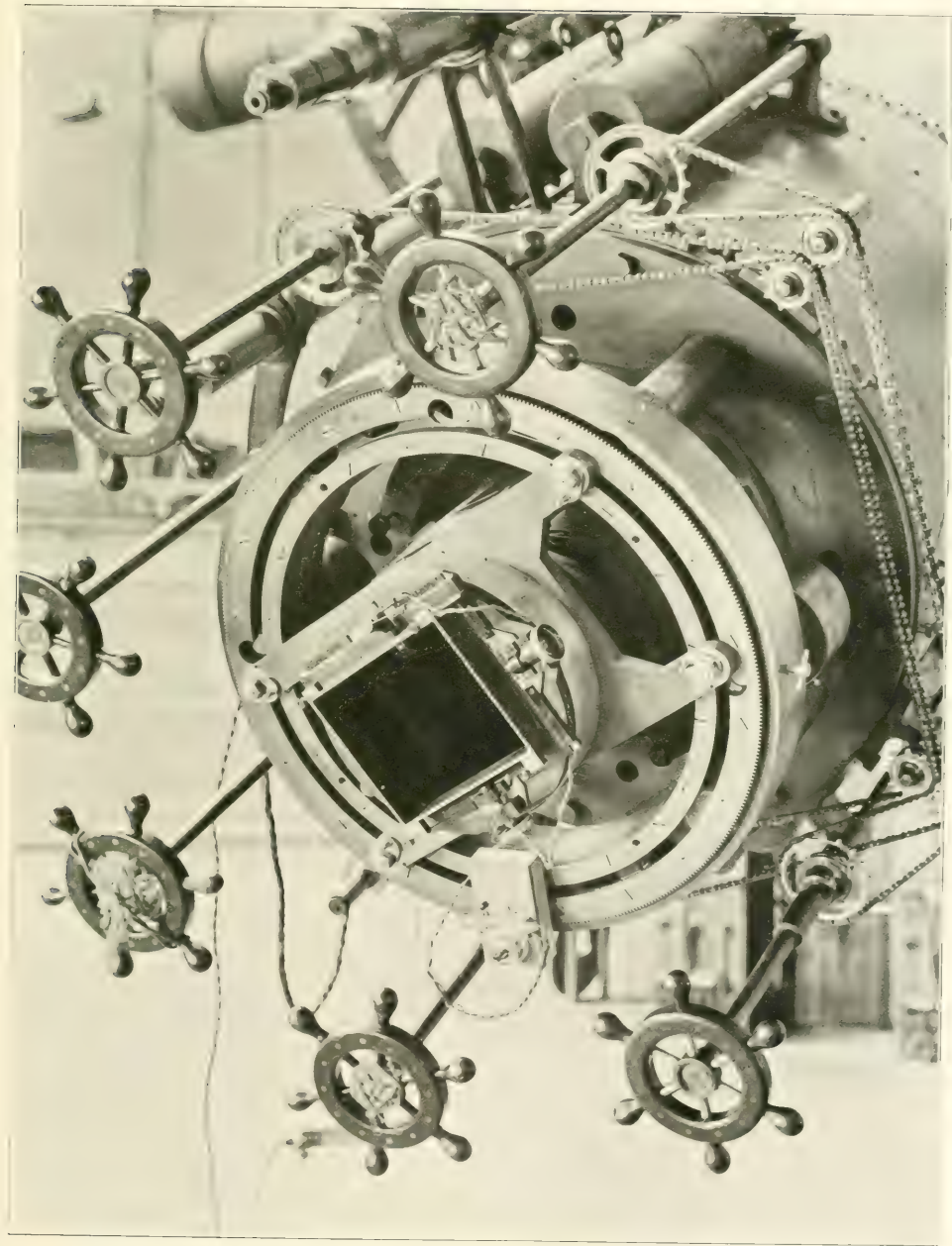
The photograph of the nebula *N. G. C. 6960* (Plate XXVII) was obtained with an exposure of four hours, and that of *N. G. C. 6992* (Plate XXVIII) with an exposure of three hours. These nebulae are the most remarkable examples of filamentous nebulae which I have photographed. They lie near together in the Milky Way in the constellation of *Cygnus*; they are apparently only the brightest parts of one great nebula, as extremely faint nebulous masses can be seen in the negatives, extending from one to the other. The nebula *N. G. C. 6960* apparently lies exactly on the boundary between the dense region of stars to the east (the right-hand side in the illustration) and the region to the west which is comparatively void of stars. Instances of this kind occur again and again, and strongly suggest some intimate physical connection between such nebulae and the dense masses of stars in their neighborhood. These photographs afford striking illustrations of the wonderful richness and complexity of structure

of the nebula, and of the importance of photography in the study of these very faint objects. When it is remembered that these photographs, showing such delicacy of detail, are obtained with a reflecting telescope of only eighteen inches aperture and ninety-three inches focal length, we can gain some idea of the results which might be obtained in the photographic study of the nebula with a thoroughly well-made reflecting telescope which would be comparable in size, cost, and refinement of workmanship with the great modern refractors.

The photograph of *Messier* 51 (Plate XXIX) was obtained with an exposure of six hours and with an aperture of 22 inches. With this long exposure and large angular aperture a very intense negative was obtained, which shows much exterior nebulosity; the latter is so faint, however, that it is almost entirely lost in the half-tone reproduction. Perhaps the most remarkable part of the very faint outer nebulosity is a great curved mass which forms a continuation of the conspicuous branch of the nebula to the extreme south; this continues toward the east, curves toward the north, and then toward the northwest, and joins the parts of the nebula to the north. The reproduction shows well the details of the two bright main branches of the spiral, and also the faint wisps and filaments between them; the latter are far beyond the reach of all telescopes visually. The faintest stars shown on the original negative are about two magnitudes fainter than those which are at the visual limit of the forty-inch refractor.

I am indebted to Mr. F. G. Pease for able assistance in securing the reflector photographs, and in preparing all of the photographic enlargements for the engraver's use. Great credit is due to the Binner-Wells Co., engravers, for the unusual care and skill with which the photographs have been reproduced.





LARGE DOUBLE-SLIDE PLATE-CARRIER ATTACHED TO FORTY-INCH REFRACTOR





LUNAR CRATER *THEOPHILUS* AND SURROUNDINGS

SCALE: 1.29 Meters to Moon's Diameter





*MARE SERENITATIS, MARE TRANQUILLITATIS, AND SURROUNDINGS*

SCALE: 0.62 Meter to Moon's Diameter





LUNAR CRATER *COPERNICUS* AND SURROUNDINGS

SCALE: 1.02 Meters to Moon's Diameter

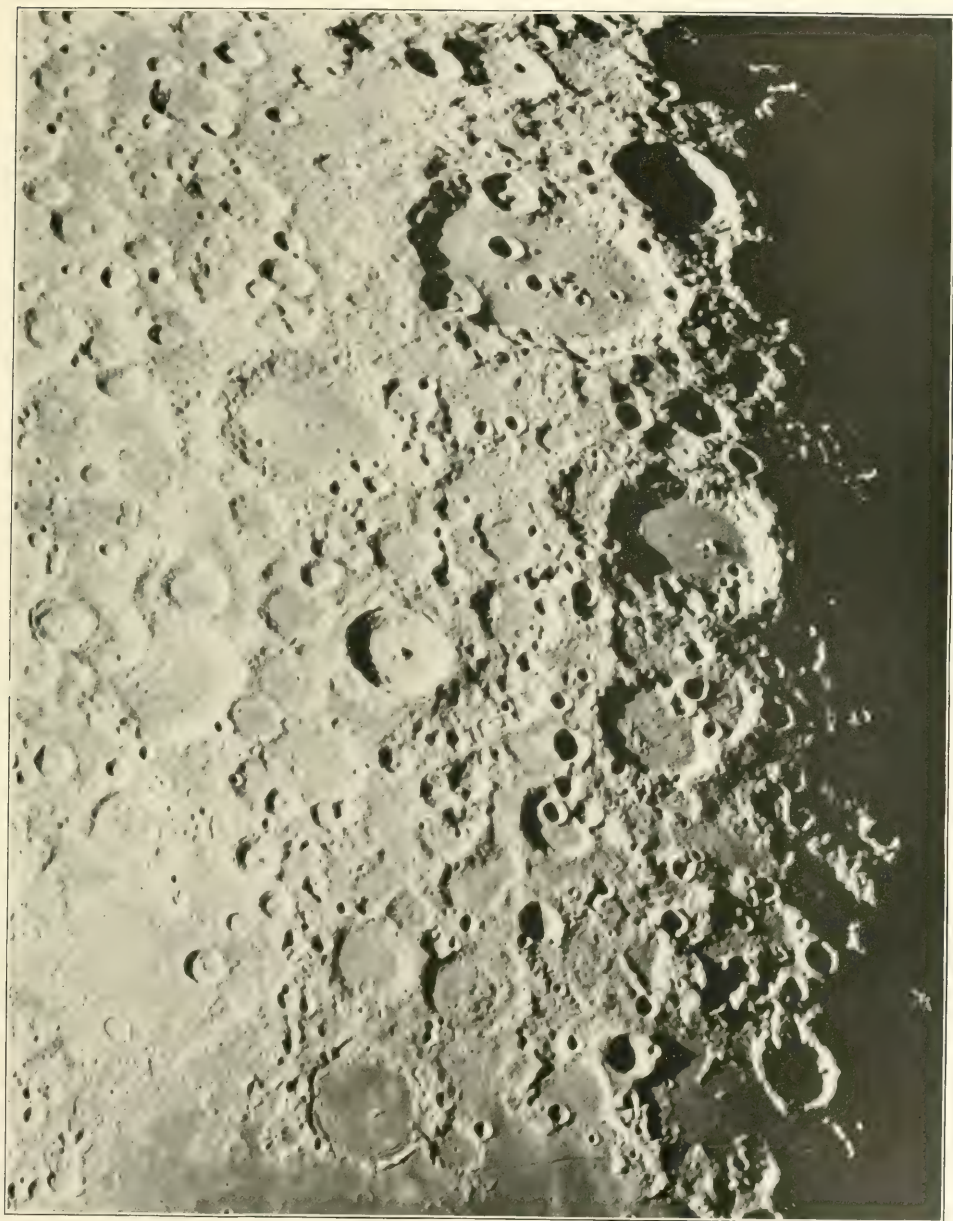




*MARE NUBIUM, BULLIADUS, ETC.*

SCALE: 0.59 Meter to Moon's Diameter





LUNAR CRATERS *CLAUUS*, *LONGOBONIANUS*, *TYCHO*, ETC.

SCALE: 0.79 Meter to Moon's Diameter





SYSTEM OF BRIGHT RAYS ABOUT *Tycho*





SCALE: 1<sup>mm</sup> = 4' 66

STAR-CLUSTER *MESSIER 13 HERCULIS*

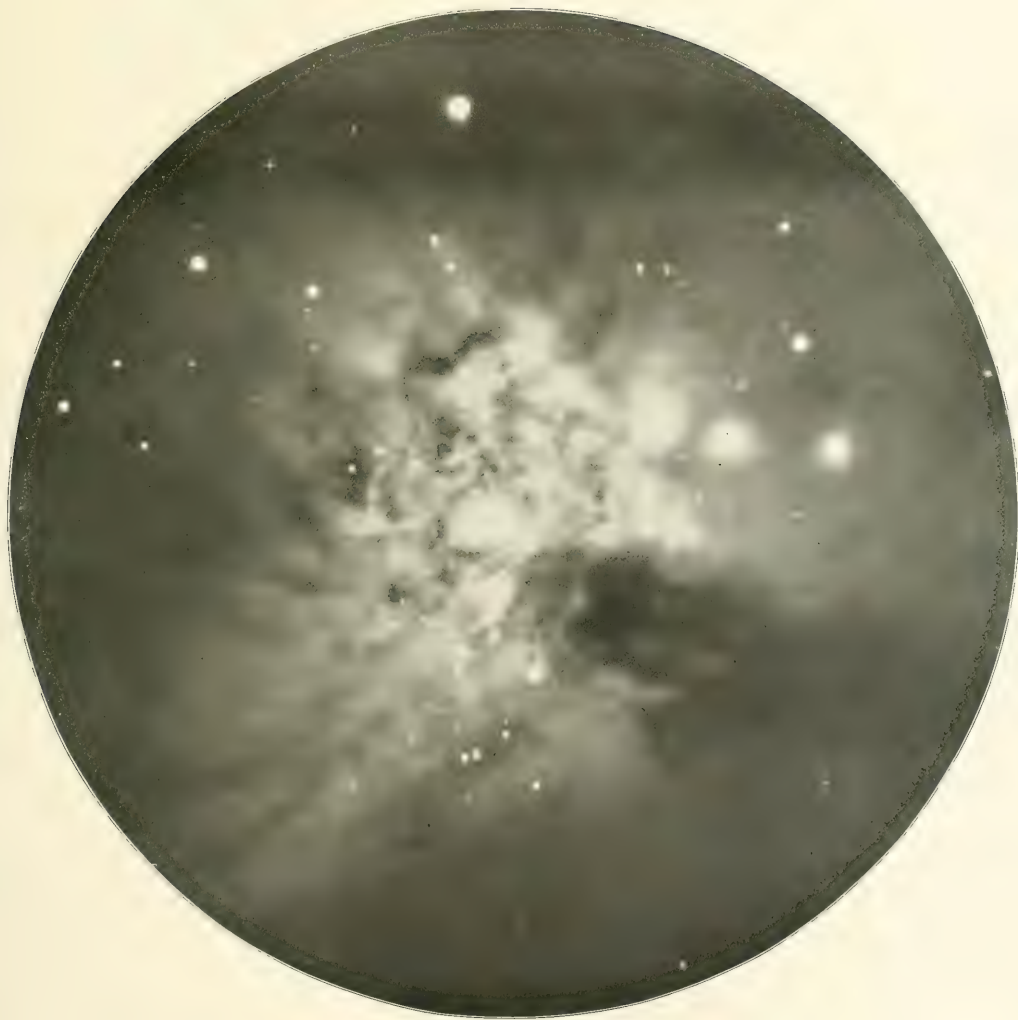




STAR-CLUSTER *MESSIER 15 PEGASI*

SCALE: 10.00 3.722

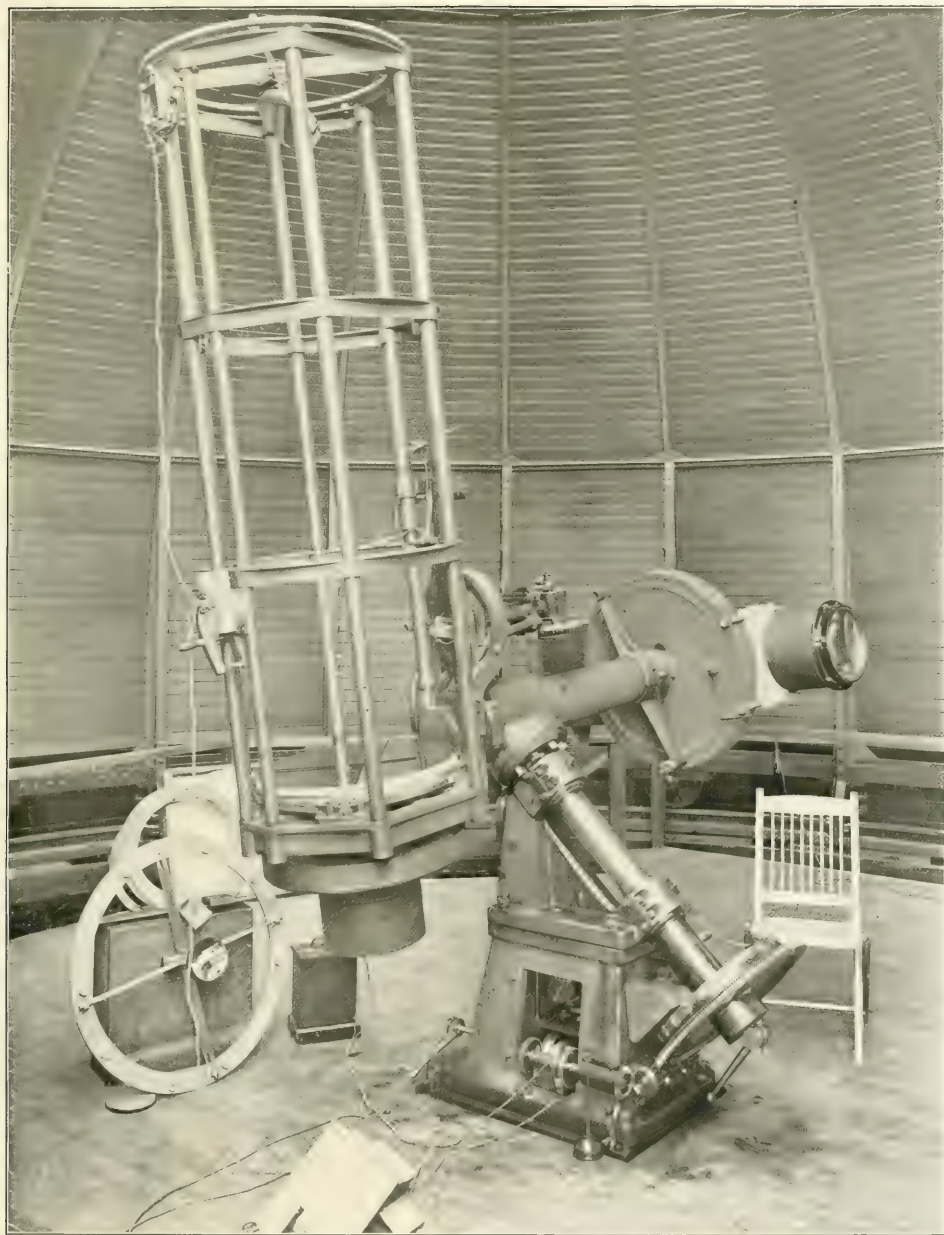




CENTRAL PART OF GREAT NEBULA IN *ORION*

SCALE: 1<sup>00</sup><sup>m</sup> - 1"





TWO-FOOT REFLECTING TELESCOPE OF THE YERKES OBSERVATORY





GREAT NEBULA IN ORION





SCALE:  $1'' = 27.75$

GREAT NEBULA IN ANDROMEDA

September 18, 1901





SCALE:  $1^{\text{mm}} = 15''.5$

SPIRAL NEBULA *MESSIER 33 TRIANGULI*

September 4 and 6, 1902





SCALE:  $1'' = 21''$

NEBULOSITY IN THE *PLEIADES*

October 19, 1901



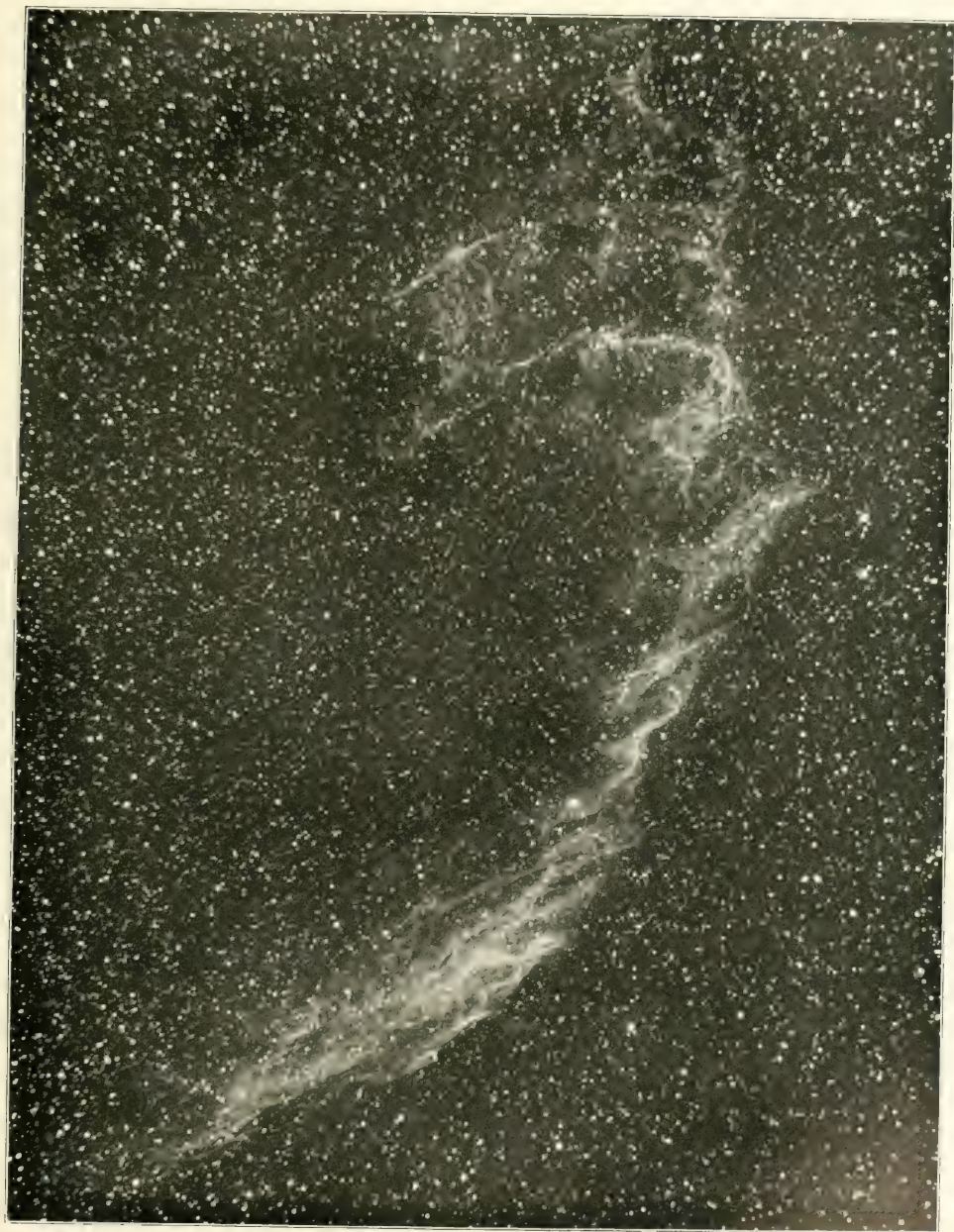


NEBULA IN *Cygnus*, N.G.C. 6960

SCALE: 1" = 18"

August 1, 1902





SCALE:  $1'' = 20''$

NEBULA IN CYGNUS, N.G.C. 6902

October 5, 1901





SCALE:  $1'' = 13.72$

SPIRAL NEBULA *MESSIER 51 CANIS VENATICORUM*

JUNE 3, 1902



# THE ORBIT OF THE MINOR PLANET (334)



# THE ORBIT OF THE MINOR PLANET (334)

KURT LAVES

## INTRODUCTION. THE MINOR PLANETS OF THE HILDA TYPE

OF the four principal types of characteristic planets those of the *Hestia* ( $\mu = \frac{1}{3}$ ) and *Hecuba* ( $\mu = \frac{1}{2}$ ) types have led to frequent and elaborate investigations. The planets of the *Hilda* ( $\mu = \frac{2}{3}$ ) and *Thule* ( $\mu = \frac{3}{4}$ ) types have so far attracted very little attention. This is due, first, to the paucity of the number of planets of these two groups, and, secondly, to the close proximity of the perturbing planet *Jupiter*, which renders the development of the perturbative function laborious and difficult. The methods best adapted for the planets of the *Hilda* and *Thule* types will most likely be that of Gylden and the periodic solution method of Poincaré. The planets of the *Hilda* type are four in number: (153), (190), (334), and (361). The characteristic elements of these planets are:<sup>1</sup>

	(153)	(190)	(334)	(361)
$n$ .....	452°197	452°998	459°742	450°396
$\phi$ .....	9 44.5	9° 19.8	0° 50.4	11° 32.9
$i$ .....	7° 52.7	6° 6.7	4° 38.1	12° 37.0

The planets of the *Hilda* and *Thule* types are in peculiar contrast to the gaps (lacunes) which occur in the regions of commensurability of the planets of the *Hestia* and *Hecuba* types. Tisserand, Gylden, Poincaré, and Callandreau have shown that the absence of planets in these regions cannot be explained by an action of *Jupiter* on these planets. Indeed, the orbits of planets which pass through values of the mean daily motion which are commensurable to that of *Jupiter* continue to be stable. In the twenty-fifth chapter of the fourth volume of his *Mécanique céleste* Tisserand has investigated whether or not there are any planets in these two realms, where *Jupiter* will bring about a librational effect. Of the *Hestia* type the planet (132) is the only one where libration is likely to occur. Tisserand points to the three planets (332), (381), and (325) of the *Hecuba* type which in the future, when their elements will be known with greater accuracy, may prove to be "librational" planets. In the table which Tisserand has given on p. 419 the planet (132) is stated to have a mean daily motion of 888".8, which is incorrect and should read 904". Planet (332) is erroneously put in the *Hecuba* group, since it really is a planet of the type  $\frac{2}{5}$ . Allowing for these changes and employing the elements as they appear in Professor Bauschinger's up-to-date table, there are left, then, three ambiguous planets, namely, (132), (381), and (325). Planet (132) has unfortunately not been observed since its first discovery by Watson in 1873; therefore very little weight can be placed upon the accuracy of its elements. As will be shown, it is the only planet of the two types where Tisserand's criterion will bring out a librational effect. The planets (381) and (325), discovered in 1894 and 1892 respectively, have been observed in five and four oppositions respectively. Their elements may therefore now be considered to be trustworthy, at least as far as is necessary for the accuracy required by Tisserand's criterion. Neither one of them shows any libration whatever. We have, therefore, as yet to find a "librational" planet belonging to either group. Extending Tisserand's investigations to the planets of the *Hilda* and *Thule* types, we encounter at once planets of a very marked librational character. Tisserand, in

<sup>1</sup>See J. BAUSCHINGER, *Tabellen zur Geschichte und Statistik der kleinen Planeten*, Tabelle II, "Veröffentlichungen des kgl. astronomischen Recheninstituts zu Berlin," No. 16.

deriving his criterion, has taken into account but one term of the perturbative function; he has integrated the differential equation for  $\theta$  [equation (1) on p. 421 of Vol. IV] as if  $h$  were a constant, which it is not; and lastly he has considered the Keplerian ellipse as a sufficient first approximation for the elements. The failure to find librational planets might therefore be considered from the standpoint of the mathematician as an indication that the method is at fault and that instability of the orbits will really take place. Such an argument is contradicted by the existence of librational planets of very marked degree, and that in the closest proximity to the perturbing planet. The attempt has been made to improve Tisserand's method in this respect that not only one of the characteristic perturbative terms is taken into account, but two. Considering the average magnitude of the eccentricity of the orbits involved, it seemed necessary not to neglect the term which carries the square of the eccentricity. It was found that the numerical results thus obtained are very little different from those obtained by Tisserand's original proceeding, but that it is considerably more laborious to obtain them. In what follows the results are given for the planets of the four groups, using Tisserand's criterion without change.

#### 1. THE HESTIA TYPE

Libration takes place if the following inequality is fulfilled:

$$(n_1 - 3n)^2 < \frac{3}{2} m' \frac{a'^2}{a^2} e^2 \sin^2 \frac{\theta_1}{2} \left( 21 b'' + 10 a' \frac{db''}{da} + a^2 \frac{d^2 b''}{da^2} \right);$$

or, reducing it to numbers for  $a = \frac{1}{3^i 9}$ , we obtain:

$$n_1 - 3n < 52.7 e \sin \frac{\theta_1}{2}.$$

For the planet (132)

$$n_1 - 3n < 6.73 < 52.7 e \sin \frac{\theta_1}{2} = 9.8.$$

The inequality is therefore fulfilled, since  $6.73 < 9.8$ .

The general formulas for planets where  $\frac{n'}{n} = \frac{i-1}{i}$  is approximately fulfilled are,  $i$  being an integer:

$$\theta = + (i-1) (L - \pi) - i (L' - \pi). \quad (1)$$

$$R = - \frac{k^2 m'}{2 a'^2} (2i A^{(0)} - A_1^{(0)}) \cos (iL' - (i-1)L - \pi). \quad (2)$$

$$h^2 = 3 (i-1) (2i A^{(0)} + A_1^{(0)}) \frac{n'^2 e}{a'^2}. \quad (3)$$

$$\frac{d^2 \theta}{dt^2} = - \frac{1}{2} m' h^2 \sin \theta. \quad (4)$$

Libration takes place if

$$n_1 - \frac{i}{i-1} n' < \frac{h}{i-1} \cos \frac{\theta_1}{2} \sqrt{2m'}. \quad (5)$$

Putting  $i = 2, 3, 4$  into these formulas, we obtain the formulas that hold for the *Hecuba*, *Hilda*, and *Thule* types respectively.

#### II. THE HECUBA TYPE

Equation (5) becomes 
$$n_1 - 2n' < 56.7 e \cos \frac{\theta_1}{2}.$$

For planet (325) the inequality becomes  $16.6 < 4.0$ .

For planet (381) the inequality becomes  $21.4 < 19.4$ .

Both of these, therefore, fail to be "librational" planets.

## III. THE HILDA TYPE

Equation (2) becomes

$$R = -\frac{k^2 m'}{2a'} e \left( 6b'' + a \frac{db''}{da} \right) \cos(2L - 3L' + \pi).$$

Equation (5) becomes

$$\left| n_1 - \frac{3}{2} n' \right| < 58.671 \bar{e} \cos \frac{\theta_1}{2}.$$

Applying this to the four planets, we obtain

	(155)	(190)	(334)	(331)
$n_1 - \frac{3}{2} n' \dots\dots\dots$	3.51	4.31	11.05	1.70
$58.671 \bar{e} \cos \frac{\theta_1}{2} \dots\dots\dots$	23.89	22.91	5.70	22.39

With the exception of (334), all of these planets have a *marked* libration.

## IV. THE THULE TYPE

The inequality (5) reduced to numbers is

$$\left| n_1 - \frac{4}{3} n' \right| < 62.701 \bar{e} \cos \frac{\theta_1}{2}.$$

For *Thule*  $n_1 - \frac{4}{3} n'$  is = 4.35, while  $62.7 \sqrt{e} \cos \frac{\theta_1}{2} = 18.39$ , which shows that libration will take place.

## THE DEVELOPMENT OF THE PERTURBATIVE FUNCTION

The minor planet (334) has been named *Chicago* by Professor M. Wolf of Heidelberg, in commemoration of the conference of astronomers and mathematicians held during the World's Exposition in the city of Chicago. The planet is marked for the small eccentricity and inclination of the orbit. It therefore suggested at once the application of Le Verrier's method of general perturbations. In a course of lectures on general perturbations given by the writer in the spring of 1896 the planet was used as an example for illustrating certain modes of computation. At that time but a limited number of observations was known, from which an orbit had been derived by Professor Berberich. The mean motion given in this system of elements was used in the computations. It was soon realized that in order to accomplish something by means of the calculations carried on to some extent by the writer and Professor Moulton in 1896, the perturbative function would have to be extended far beyond the original scope. For a few years the computations were allowed to rest and when taken up again by the writer they were continued with the same value of the mean daily motion, since a recomputation of the previous work seemed unnecessary. For a determination of the mean value of the major axis the set of available observations seemed insufficient. It was therefore argued that if osculating elements were to be used, an epoch of the elements could be determined in such a manner as to bring the value of the major axis used in the computations as near as possible to the major axis of the epoch to be selected. By means of special perturbations the change of the major axis between 1897 and 1894 due to the action of Jupiter was determined, and it was found that the major axis passed, during this interval of time, through the value assumed in the computations. The tables constructed will be of usefulness, too, if at some future epoch new tables of the planet shall be constructed, even if the mean value of the major axis shall appreciably differ from the value employed here. Indeed, by a differential method the change can be taken

into account without very much labor. Pains have been taken to avoid errors in the computations. The coefficients  $b^{(i)}$ ,  $b_1^{(i)}$ ,  $b_2^{(i)}$ ,  $c^{(i)}$ ,  $c_1^{(i)}$  from  $i = 0$  to  $i = 15$  and the quantities which depend only upon these were computed independently by Mr. Moulton and myself. The other coefficients were almost all of them checked by a repeated calculation in which the calculating machine was used. To enable a checking of any part of the work all the necessary quantities are given from the beginning. It may prove necessary in the second part of this investigation, which will be published at an early date, to add a number of terms which at the present state of the work seemed to be negligible. The planet has been observed in eight oppositions, nine oppositions having occurred since its discovery. It is to be hoped that it will prove in the future to be an object from which much valuable information may be obtained, a new determination of the mass of Jupiter appearing to be of the most immediate importance.

In developing the perturbative function the value of  $a = \frac{a}{a'}$  was assumed to be 0.7543102  $\log a = 9.8775500$ .

The development of this function necessitates the calculation of the coefficients of the Fourier series into which  $(1 + a^2 - 2a \cos \psi)^{-s}$  is to be developed, when  $s$  takes the values  $\frac{1}{2}$ ,  $\frac{3}{2}$ ,  $\frac{5}{2}$ ,  $\frac{7}{2}$ . The designations used in what follows are those of Le Verrier (see *Annales de l'Observatoire de Paris*, Vol. X). We therefore put

$$\begin{aligned}(1 + a^2 - 2a \cos \psi)^{-\frac{1}{2}} &= \sum b^{(s)} \cos i\psi, \\(1 + a^2 - 2a \cos \psi)^{-\frac{3}{2}} &= \sum c^{(i)} \cos i\psi, \\(1 + a^2 - 2a \cos \psi)^{-\frac{5}{2}} &= \sum e^{(i)} \cos i\psi, \\(1 + a^2 - 2a \cos \psi)^{-\frac{7}{2}} &= \sum f^{(i)} \cos i\psi.\end{aligned}\tag{1}$$

Only one-half of the absolute terms are to be taken in these developments.

Each of the coefficients  $b^{(i)}$ ,  $c^{(i)}$ ,  $e^{(i)}$ ,  $f^{(i)}$  is given by means of power series in  $a$ , the coefficients of which depend upon the respective values of  $s$ . In the second volume of the *Annales* Le Verrier has given these coefficients of the various powers of  $a$  with sufficient accuracy. Recursion formulas are easily obtainable by means of which the higher  $b^{(i)}$ ,  $c^{(i)}$ , . . . may be calculated when the lower ones are known. On account of the slow convergence of the series it was deemed necessary to compute the coefficients  $b^{(i)}$ , and  $c^{(i)}$  up to and including the term for which  $i$  is equal to 30.

In Le Verrier's method the perturbative function is developed, by Taylor's principle, by starting from the circular form of the orbit. Owing to the small value of the eccentricity of (334), a close approach to the true orbit should be obtained by stopping at the fourth degree terms in the periodic terms, and carrying the development up to the sixth degree in the secular terms.

$$R_1 = (r^2 + r'^2 - 2rr' \cos \psi)^{-\frac{1}{2}} = \frac{r r'^2}{r'^2}.$$

is the expression for the perturbative function. From the development given above the  $A'$ ,  $B'$ ,  $C'$ ,  $D'$  coefficients are derived by means of the formulas:

$$\begin{aligned}(a^2 + a'^2 - 2aa' \cos \psi)^{-\frac{1}{2}} &= \frac{1}{2} \sum A^{(i)} \cos i\psi, \\aa'(a^2 + a'^2 - 2aa' \cos \psi)^{-\frac{3}{2}} &= \frac{1}{2} \sum B^{(i)} \cos i\psi, \\a^2a' - (a^2 + a'^2 - 2aa' \cos \psi)^{-\frac{5}{2}} &= \frac{1}{2} \sum C^{(i)} \cos i\psi.\end{aligned}\tag{2}$$

Comparing set (1) with (2) it follows that we have:

$$\begin{aligned}
 a' A^{(n)} &= b^{(n)} & a' B^{(n)} &= a c^{(n)} \\
 a' A_1^{(n)} &= b_1^{(n)} & a' B_1^{(n)} &= a (c_1^{(n)} + c^{(n)}) \\
 a' A_2^{(n)} &= \frac{1}{2} b_2^{(n)} & a' B_2^{(n)} &= \frac{a}{2} (c_2^{(n)} + 2c_1^{(n)}) \\
 a' A_3^{(n)} &= \frac{1}{2 \cdot 3} b_3^{(n)} & a' B_3^{(n)} &= \frac{a}{2 \cdot 3} (c_3^{(n)} + 3c_2^{(n)}) \\
 a' A_4^{(n)} &= \frac{1}{2 \cdot 3 \cdot 4} b_4^{(n)} & a' C^{(n)} &= a^2 e^{(n)} \\
 a' A_5^{(n)} &= \frac{1}{2 \cdot 3 \cdot 4 \cdot 5} b_5^{(n)} & a' C_1^{(n)} &= a^2 (e_1^{(n)} + 2e^{(n)}) \\
 \\ 
 a' E^{(n)} &= \frac{1}{2} (a' B^{(n-1)} + a' B^{(n+1)}) \\
 a' G^{(n)} &= \frac{3}{8} (a' C^{(n-2)} + 4a' C^{(n)} + a' C^{(n+2)}) \\
 a' L^{(n)} &= \frac{3}{4} (a' C^{(n-2)} + a' C^{(n)})
 \end{aligned}$$

The development for  $R_1 = (r^2 + r'^2 - 2rr' \cos \psi)^{-\frac{1}{2}}$  will be obtained by means of the foregoing formulas; this being done,  $R_0$  is deduced from it. Those coefficients of  $R_0$  which are affected by the development of  $\frac{r \cos \psi}{r'^2}$  are given at the bottom of each table with the proper designation. In the six differential equations for the elements will enter the partial differential quotients of  $R_0$  with respect to the various elements involved. For all of them except  $\frac{\partial R_0}{\partial a}$  the coefficients that hold for  $R_0$  will be the same. It is therefore necessary to give for  $\frac{\partial R_0}{\partial a}$  a special development. The calculation for the coefficients of this quantity rests upon the following formulas, which closely resemble the foregoing formulas:

$$\begin{aligned}
 a' a \frac{dA^{(n)}}{da} &= a' A_1^{(n)} & a' a \frac{dA_1^{(n)}}{da} &= 5a' A_2^{(n)} + 4a' A_4^{(n)} \\
 a' a \frac{dA_1^{(n)}}{da} &= 2a' A_2^{(n)} + a' A_4^{(n)} & a' a \frac{dB^{(n)}}{da} &= a' B_1^{(n)} \\
 a' a \frac{dA_2^{(n)}}{da} &= 3a' A_3^{(n)} + 2a' A_5^{(n)} & a' a \frac{dB_1^{(n)}}{da} &= 2a' B_2^{(n)} + a' B_4^{(n)} \\
 a' a \frac{dA_3^{(n)}}{da} &= 4a' A_4^{(n)} + 3a' A_6^{(n)} \\
 \\ 
 a' a \frac{dB_2^{(n)}}{da} &= 3a' B_3^{(n)} + 2a' B_5^{(n)} \\
 a' a \frac{dC^{(n)}}{da} &= a' C_1^{(n)} \\
 a' a \frac{dC_1^{(n)}}{da} &= 2a' C_2^{(n)} + a' C_3^{(n)} \\
 a' a \frac{dE^{(n)}}{da} &= \frac{1}{2} \left( a' a \frac{dB^{(n-1)}}{da} + a' a \frac{dB^{(n+1)}}{da} \right) \\
 a' a \frac{dG^{(n)}}{da} &= \frac{3}{8} \left( a' a \frac{dC^{(n-2)}}{da} + 4a' a \frac{dC^{(n)}}{da} + a' a \frac{dC^{(n+2)}}{da} \right) \\
 a' a \frac{dL^{(n)}}{da} &= \frac{3}{4} \left( a' a \frac{dC^{(n-2)}}{da} + a' a \frac{dC^{(n)}}{da} \right)
 \end{aligned}$$

# THE ORBIT OF THE MINOR PLANET (334)

TABLE I

$i$	$b_1$	$b_1^{(1)}$	$b_2^{(1)}$	$b_3^{(1)}$	$b_4^{(1)}$	$b_5^{(1)}$	$b_6^{(1)}$
0	2.441395	1.443403	5.590232	34.898984	327.1807	4050.409	62512.41
1	1.016735	1.913541	5.497506	35.271067	327.9349	4057.947	62583.87
2	0.596121	1.785029	6.069221	35.749825	331.2201	4079.383	63106.04
3	0.381915	1.549698	6.483219	37.527031	336.3891	4117.862	63128.86
4	0.255109	1.300851	6.552158	39.806480	346.1931	4174.097	.....
5	0.174627	1.070263	6.351655	41.821026	360.6489	4258.352	.....
6	0.121483	0.868749	5.958702	43.089983	377.7704	4378.645	.....
7	0.085489	0.698334	5.447238	43.404727	394.8075	4534.445	.....
8	0.060680	0.557208	4.877527	42.753952	409.1497	4716.083	.....
9	0.043359	0.442019	4.294311	41.247667	418.8124	4899.008	.....
10	0.031148	0.348991	3.728425	39.057161	422.5994	5089.724	.....
11	0.022475	0.274477	3.199295	36.374347	420.0530	5236.467	.....
12	0.016276	0.215164	2.718241	33.37593	411.4613	5355.954	.....
13	0.011823	0.168201	2.289570	30.23708	397.1126	5410.922	.....
14	0.008612	0.131167	1.914574	27.06107	378.7607	5406.813	.....
15	0.006287	0.102078	1.590132	23.99735	355.6490	5355.452	.....
16	0.004599	0.079289	1.3137	21.0520	.....	.....	.....
17	0.003370	0.061493	1.0789	18.3651	.....	.....	.....
18	0.002473	0.047622	0.8831	15.8222	.....	.....	.....
19	0.001817	0.036835	0.7186	13.656	.....	.....	.....
20	0.001337	0.028450	0.5840	11.554	.....	.....	.....
21	0.000985	0.021967	0.4711	9.942	.....	.....	.....
22	0.000726	0.016944	0.3810	8.214	.....	.....	.....
23	0.000536	0.013050	0.3050	7.136	.....	.....	.....
24	0.000396	0.010066	0.2450	5.712	.....	.....	.....
25	0.000293	0.007735	0.1956	5.048	.....	.....	.....
26	0.000217	0.005971	0.1551	3.922	.....	.....	.....
27	0.000161	0.004575	0.1246	3.476	.....	.....	.....
28	0.000120	0.003527	0.0964	2.754	.....	.....	.....
29	0.000090	0.002687	0.0791	2.281	.....	.....	.....
30	0.000068	0.002065	0.0587	2.066	.....	.....	.....

$i$	$e_0^{(1)}$	$e_1^{(1)}$	$e_2^{(1)}$	$e_3^{(1)}$	$e_4^{(1)}$	$e_5^{(1)}$	$e_6^{(1)}$
0	12.36175	68.6237	621.7857	7553.544	134.8231	1582.967	.....
1	11.23813	68.4992	618.8126	7538.537	132.0236	1570.668	.....
2	9.66595	66.2459	611.9514	7489.341	124.8907	1532.359	.....
3	8.0770	62.1949	599.078	7408.474	114.9379	.....	.....
4	6.6281	56.9571	578.959	7289.902	103.4751	.....	.....
5	5.3714	51.1037	551.770	7128.134	91.5053	.....	.....
6	4.3130	45.0838	518.578	6916.374	.....	.....	.....
7	3.4387	39.2155	480.757	.....	.....	.....	.....
8	2.7263	33.7093	440.218	.....	.....	.....	.....
9	2.1517	28.6831	398.372	.....	.....	.....	.....
10	1.6917	24.1970	356.748	.....	.....	.....	.....
11	1.3258	20.2550	316.409	.....	.....	.....	.....
12	1.0392	16.8471	278.092	.....	.....	.....	.....
13	0.8079	13.9271	242.629	.....	.....	.....	.....
14	0.6286	11.4574	209.897	.....	.....	.....	.....
15	0.4882	9.407	180.256	.....	.....	.....	.....
16	0.3786	.....	.....	.....	.....	.....	.....
17	0.2932	.....	.....	.....	.....	.....	.....
18	0.2298	.....	.....	.....	.....	.....	.....
19	0.1751	.....	.....	.....	.....	.....	.....
20	0.1350	.....	.....	.....	.....	.....	.....
21	0.1041	.....	.....	.....	.....	.....	.....
22	0.0802	.....	.....	.....	.....	.....	.....
23	0.0616	.....	.....	.....	.....	.....	.....
24	0.0477	.....	.....	.....	.....	.....	.....
25	0.0367	.....	.....	.....	.....	.....	.....
26	0.0279	.....	.....	.....	.....	.....	.....
27	0.0212	.....	.....	.....	.....	.....	.....
28	0.0161	.....	.....	.....	.....	.....	.....
29	0.0122	.....	.....	.....	.....	.....	.....
30	0.0092	.....	.....	.....	.....	.....	.....

TABLE II

$i$	$a \cdot A^{(1)}$	$a \cdot A_1^{(1)}$	$a \cdot A_2^{(1)}$	$a \cdot A_3^{(1)}$	$a \cdot A_4^{(1)}$	$a \cdot A_5^{(1)}$	$a \cdot A_6^{(1)}$	$a \cdot B^{(1)}$	$a \cdot B_1^{(1)}$	$a \cdot B_2^{(1)}$	$a \cdot B_3^{(1)}$	$a \cdot C^{(1)}$
0	2.441905	1.443403	2.795116	5.816497	13.63253	33.7534	86.823	9.3245	61.0871	286.2732	1184.125	76.7122
1	1.016735	1.913541	2.748753	5.878511	13.66395	33.8162	86.923	8.4770	60.1466	285.0504	1181.117	75.1193
2	0.596121	1.785029	3.049610	5.958304	13.80084	33.9949	87.647	7.2911	57.2610	282.2646	1172.344	71.0008
3	0.381915	1.549698	3.241609	6.254505	14.01621	34.3155	87.679	6.0826	53.0066	272.860	1157.323	65.398
4	0.255109	1.300851	3.276079	6.634413	14.42472	34.7841	.....	4.9096	47.9630	261.321	1134.829	58.876
5	0.174627	1.070263	3.175827	6.970171	15.02704	35.4863	.....	4.0508	42.5997	246.651	1104.237	52.065
6	0.121483	0.868749	2.979351	7.181664	15.74014	36.4887	.....	3.2533	37.2605	221.592	1065.096	.....
7	0.085489	0.698334	2.723619	7.234121	16.41261	37.7870	.....	2.5938	32.1745	210.900	.....	.....
8	0.060680	0.557208	2.438763	7.125658	17.04793	39.3007	.....	2.0565	27.4837	191.457	.....	.....
9	0.043359	0.442019	2.147155	6.874611	17.41283	40.8251	.....	1.6231	23.2590	171.507	.....	.....
10	0.031148	0.348991	1.864212	6.506527	17.69258	42.4144	.....	1.2761	19.5281	152.805	.....	.....
11	0.022475	0.274477	1.599647	6.062391	17.46452	43.6372	.....	1.0001	16.2786	134.614	.....	.....
12	0.016276	0.215164	1.359120	5.562655	17.22759	44.6329	.....	0.7816	13.4896	117.592	.....	.....
13	0.011823	0.168201	1.144785	5.039513	16.50868	45.0910	.....	0.6094	11.1148	102.014	.....	.....
14	0.008612	0.131167	0.957287	4.510178	15.86506	45.0568	.....	0.4742	9.1166	87.806	.....	.....
15	0.006287	0.102078	0.785066	3.999559	.....	44.6288	.....	0.3682	.....	75.080	.....	.....
16	0.004509	0.079289	0.65685	3.5087	.....	.....	.....	0.2856	.....	.....	.....	.....
17	0.003370	0.061493	0.55947	3.0608	.....	.....	.....	0.2212	.....	.....	.....	.....
18	0.002473	0.047622	0.44155	2.6367	.....	.....	.....	0.1711	.....	.....	.....	.....
19	0.001817	0.036835	0.3593	2.2760	.....	.....	.....	0.1321	.....	.....	.....	.....
20	0.001337	0.028450	0.2920	1.9257	.....	.....	.....	0.1018	.....	.....	.....	.....
21	0.000885	0.021967	0.2355	1.6570	.....	.....	.....	0.0785	.....	.....	.....	.....
22	0.000726	0.016944	0.1905	1.369	.....	.....	.....	0.0605	.....	.....	.....	.....
23	0.000536	0.013050	0.1525	1.189	.....	.....	.....	0.0465	.....	.....	.....	.....
24	0.000386	0.010066	0.1225	0.952	.....	.....	.....	0.0357	.....	.....	.....	.....
25	0.000293	0.007735	0.0978	0.841	.....	.....	.....	0.0274	.....	.....	.....	.....
26	0.000217	0.005971	0.0775	0.654	.....	.....	.....	0.0210	.....	.....	.....	.....
27	0.000161	0.004575	0.0623	0.579	.....	.....	.....	0.0160	.....	.....	.....	.....
28	0.000120	0.003527	0.0482	0.459	.....	.....	.....	0.0121	.....	.....	.....	.....
29	0.000060	0.002687	0.0395	0.380	.....	.....	.....	0.0092	.....	.....	.....	.....
30	0.000008	0.002065	0.0298	0.344	.....	.....	.....	0.0069	.....	.....	.....	.....

$i$	$a \cdot \frac{dA^{(1)}}{da}$	$a \cdot \frac{dA_1^{(1)}}{da}$	$a \cdot \frac{dA_2^{(1)}}{da}$	$a \cdot \frac{dA_3^{(1)}}{da}$	$a \cdot \frac{dA_4^{(1)}}{da}$	$a \cdot \frac{dA_5^{(1)}}{da}$	$a \cdot \frac{dA_6^{(1)}}{da}$	$a \cdot \frac{dB^{(1)}}{da}$	$a \cdot \frac{dB_1^{(1)}}{da}$	$a \cdot \frac{dB_2^{(1)}}{da}$	$a \cdot \frac{dB_3^{(1)}}{da}$	$a \cdot \frac{dC^{(1)}}{da}$
0	1.443403	7.033635	23.039723	71.979611	223.2871	61.0871	633.6278	4124.921	60.1466	630.247	4113.451	.....
1	1.913541	7.411047	23.133039	72.291333	223.7368	60.1466	630.2333	4113.452	59.1740	627.711	4103.241	.....
2	1.785029	7.844250	23.974133	73.078272	225.1779	57.2610	621.7829	4081.56	56.5766	616.614	4115.570	.....
3	1.549698	8.032917	25.246734	74.828355	226.6423	53.0066	602.981	4117.69	52.6120	598.719	4004.345	.....
4	1.300851	7.853009	26.455397	77.602119	231.6194	47.9630	575.649	3927.13	47.8032	572.123	3961.801	.....
5	1.070263	7.421918	27.262168	81.018673	237.5397	42.5997	541.265	3806.01	42.6115	530.716	3782.800	.....
6	0.868749	6.827451	27.503694	84.506752	245.1053	37.2605	485.784	3638.47	37.3871	500.162	.....	.....
7	0.698334	6.145572	27.149601	87.352803	254.5854	32.1745	459.060	.....	32.3721	450.436	.....	.....
8	0.557208	5.434735	26.254501	89.568894	264.7029	27.4837	415.088	.....	27.7167	409.779	.....	.....
9	0.442019	4.736330	24.918144	90.275153	273.7698	23.2590	390.498	.....	23.5019	371.978	.....	.....
10	0.348991	4.077416	23.257006	90.298901	282.8423	19.5281	328.809	.....	19.7688	324.647	.....	.....
11	0.274477	3.473772	21.386468	88.045253	288.0441	16.2786	288.736	.....	16.5088	290.166	.....	.....
12	0.215164	2.933405	19.406260	85.598325	292.0749	13.4896	251.463	.....	13.6967	253.137	.....	.....
13	0.168201	2.457771	17.408109	81.153259	291.4897	11.1148	217.518	.....	11.3031	219.085	.....	.....
14	0.131167	2.045741	15.445108	76.990786	.....	9.1166	186.727	.....	.....	188.397	.....	.....
15	0.102078	1.692210	13.588809	.....	.....	.....	159.277	.....	.....	.....	.....	.....
16	0.079289	1.3930	11.8398	.....	.....	.....	.....	.....	.....	.....	.....	.....
17	0.061493	1.1404	10.2613	.....	.....	.....	.....	.....	.....	.....	.....	.....
18	0.047622	0.9307	8.7932	.....	.....	.....	.....	.....	.....	.....	.....	.....
19	0.036835	0.7534	7.5466	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	0.028450	0.6124	6.3611	.....	.....	.....	.....	.....	.....	.....	.....	.....
21	0.021967	0.4931	5.4421	.....	.....	.....	.....	.....	.....	.....	.....	.....
22	0.016944	0.3979	4.4883	.....	.....	.....	.....	.....	.....	.....	.....	.....
23	0.013050	0.3180	3.8720	.....	.....	.....	.....	.....	.....	.....	.....	.....
24	0.010066	0.2551	3.1010	.....	.....	.....	.....	.....	.....	.....	.....	.....
25	0.007735	0.2033	2.7186	.....	.....	.....	.....	.....	.....	.....	.....	.....
26	0.005971	0.1611	2.1171	.....	.....	.....	.....	.....	.....	.....	.....	.....
27	0.004575	0.1292	1.8616	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	0.003527	0.0949	1.4734	.....	.....	.....	.....	.....	.....	.....	.....	.....
29	0.002687	0.0818	1.2191	.....	.....	.....	.....	.....	.....	.....	.....	.....
30	0.002065	0.0608	1.0907	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE III  
THE SECULAR PART OF  $a' R_1$  AND  $a' a \frac{dR_1}{da}$

	$e R_1$	$a' a \frac{dR_1}{da}$		$a' R_1$	$a' a \frac{dR_1}{da}$
	+0.0865018	+9.8583567	$e^2 e'^2 \cos(2\pi' - 2\omega) \dots$	+0.99969	+2.15413
	+0.0251538	+0.8761220	$e^3 \eta' \cos(2\omega - 2\pi') \dots$	+1.78790	+2.86277
	+0.0251538	+0.8761220	$a' \eta' \cos(\pi' + \omega - 2\pi') \dots$	-1.92947	-3.06977
	-0.6272122	-1.4781822	$e'^2 \eta' \cos(2\pi' - 2\pi') \dots$	+1.46501	+2.64637
$ee \cos(\pi' - \omega) \dots$	-0.2607341	-1.1557895	$e^2 \dots$	+1.27508	
$e^2 \dots$	+0.56190	+1.74322	$e^4 e'^2 \dots$	+2.43034	
$e^3 \dots$	+1.33401	+2.47198	$e^2 e'^4 \dots$	+2.62632	
$e^4 \dots$	+0.88484	+1.98512	$e^6 \dots$	+1.87452	
$e^5 \dots$	-1.93500	-3.07405	$e^6 e' \cos(\pi' - \omega) \dots$	-1.15232	
$e^6 \dots$	-1.93500	-3.07405	$e^3 e'^3 \cos(\pi' - \omega) \dots$	-2.82749	
$e^7 \dots$	+1.76281	+3.06850	$e e'^5 \cos(\pi' - \omega) \dots$	-2.54231	
$e^5 e' \cos(\pi' - \omega) \dots$	-1.24424	-2.40640	$e^4 e'^2 \cos(2\pi' - 2\omega) \dots$	+2.24628	
$ee'^3 \cos(\pi' - \omega) \dots$	-1.40074	-2.52614	$e^2 e'^4 \cos(2\pi' - 2\omega) \dots$	+2.43887	
$ee^2 e' \cos(\pi' - \omega) \dots$	+2.22418	+3.36840	$e^3 e'^3 \cos(3\pi' - 3\omega) \dots$	-1.85230	

TABLE IV  
THE PERIODIC PART OF  $R_{20}$  AND  $a' a \frac{dR_{20}}{da}$

	$a R_1$	$a' a \frac{dR_1}{da}$		$a R_1$	$a' a \frac{dR_1}{da}$
$\cos(l' - \lambda)^*$	0.00721	+0.28184	$e^2 \cos(5l' - \lambda)$	-0.35075	-0.97380
(2l' - 2λ)	9.77533	0.25164	6 ( " )	-0.38904	-1.14951
(3l' - 3λ)	9.58197	0.19025	7 ( " )	-0.39410	-1.24479
(4l' - 4λ)	9.40673	0.11423	8 ( " )	-0.37758	-1.29703
(5l' - 5λ)	9.24211	0.02949	9 ( " )	-0.34586	-1.32173
(6l' - 6λ)	9.08452	9.93889	10 ( " )	-0.30281	-1.32699
(7l' - 7λ)	8.93191	8.84406	11 ( " )	-0.25101	-1.31708
(8l' - 8λ)	8.78305	9.74692	12 ( " )	-0.19218	-1.29697
(9l' - 9λ)	8.63708	9.64544	13 ( " )	-0.12762	-1.26701
(10l' - 10λ)	8.49343	9.54284	14 ( " )	-0.05835	-1.22951
(11l' - 11λ)	8.35170	9.43851	15 ( " )	-9.98498	-1.18546
(12l' - 12λ)	8.21155	9.33277	$e^2 \cos(1l' - \lambda)^*$	+0.11873	+1.12581
(13l' - 13λ)	8.07273	9.22583	2 ( " )	+8.51634	+0.94394
(14l' - 14λ)	7.93510	9.11782	3 ( " )	-0.01770	+0.43016
(15l' - 15λ)	7.79844	9.00893	4 ( " )	-0.25362	-0.56341
(16l' - 16λ)	7.66266	8.89921	5 ( " )	-0.35075	-0.97380
(17l' - 17λ)	7.52763	8.78883	6 ( " )	-0.38904	-1.14951
(18l' - 18λ)	7.39322	8.67781	7 ( " )	-0.39410	-1.24479
(19l' - 19λ)	7.25965	8.56626	8 ( " )	-0.37758	-1.29703
(20l' - 20λ)	7.12613	8.45408	9 ( " )	-0.34586	-1.32173
(21l' - 21λ)	6.99344	8.34177	10 ( " )	-0.30281	-1.32699
(22l' - 22λ)	6.86194	8.22920	11 ( " )	-0.25101	-1.31708
(23l' - 23λ)	6.72916	8.11561	12 ( " )	-0.19218	-1.29697
(24l' - 24λ)	6.59770	8.00246	13 ( " )	-0.12762	-1.26701
(25l' - 25λ)	6.46687	7.88846	14 ( " )	-0.05835	-1.22951
(26l' - 26λ)	6.33646	7.77495	15 ( " )	-9.98498	-1.18546
(27l' - 27λ)	6.20683	7.66139	16 ( " )	-9.98498	-1.10319
(28l' - 28λ)	6.07818	7.54741	17 ( " )	-9.82827	-1.08171
$e^2 \cos(1l' - \lambda)^*$	+0.11873	+1.12581	18 ( " )	-9.74554	-1.02385
2 ( " )	+8.51634	+0.94394	19 ( " )	-9.69068	-0.96123
3 ( " )	-0.01770	+0.43016	20 ( " )	-9.57357	-0.89724
4 ( " )	-0.25362	-0.56341	21 ( " )	-9.48515	-0.82730

	$a' R_1$	$a' a \frac{dR_1}{da}$		$a R_1$	$a' a \frac{dR_1}{da}$
$e^2 \cos(1l' - \lambda)^*$	0.11873	+1.12581	$2e^2 \cos(1l' - \lambda)$	0.23828	1.13790
$2e^2 \cos(1l' - \lambda)$	0.23828	1.13790			

TABLE IV (continued)

	$a R_1$	$a a \frac{dR_1}{da}$		$a R_1$	$a a \frac{dR_1}{da}$
$e \cos 22^\circ l - \lambda$	-9.39375	-0.76103	$e \cos (-15l' - 19\lambda - \omega)$	+8.63615	+9.83573
23 " "	-9.30276	-0.68869	$(-14l' + 15\lambda - \omega)$	+8.70024	+9.91034
24 " "	-9.20868	-0.61236	$(-13l' - 11\lambda - \omega)$	+8.84260	+9.98124
25 " "	-9.11528	-0.53135	$(-12l' - 13\lambda - \omega)$	+8.94315	+0.04738
26 " "	-9.01870	-0.42275	$(-11l' - 12\lambda - \omega)$	+8.96664	+0.10800
27 " "	-8.92376	-0.36884	$(-10l' - 11\lambda - \omega)$	+9.13667	+0.16173
$\eta^2 \cos 1^\circ l - \lambda$	-0.91949	-1.77208	$(-9l' - 10\lambda - \omega)$	+9.22846	+0.20683
2 " "	-0.86242	-1.75256	$(-8l' - 9\lambda - \omega)$	+9.31558	+0.24062
3 " "	-0.78855	-1.72103	$(-7l' - 8\lambda - \omega)$	+9.39664	+0.25901
4 " "	-0.70515	-1.67940	$(-6l' - 7\lambda - \omega)$	+9.46912	+0.25498
5 " "	-0.61557	-1.61780	$(-5l' - 6\lambda - \omega)$	+9.52892	+0.21495
6 " "	-0.52144	-1.57267	$(-4l' - 5\lambda - \omega)$	+9.56825	+0.10616
7 " "	-0.42405	-1.49467	$(-3l' - 4\lambda - \omega)$	+9.59925	+9.80115
8 " "	-0.32366	-1.44270	$(-2l' - 3\lambda - \omega)$	+9.47673	+9.57082
9 " "	-0.22689	-1.37112	$(-1l' - 2\lambda - \omega)$	+8.77790	+0.25333
10 " "	-0.11780	-1.29593	$(0 - 1\lambda - \omega)$	+9.85896	+0.54615
11 " "	-0.01235	-1.19052	$(+1l' - 0 - \omega)$	-0.29524	+0.74966
12 " "	-9.90596	-1.13657	$(+2l' - 1\lambda - \omega)$	-0.31905	+0.87577
13 " "	-9.7941	.....	$(+3l' - 2\lambda - \omega)$	-0.28341	+0.93780
14 " "	-9.6874	.....	$(+4l' - 3\lambda - \omega)$	-0.22294	+0.96047
$e \cos (-14l' + 14\lambda - \pi - \omega)$	+9.96354	+1.16320	$(+5l' - 4\lambda - \omega)$	-0.14808	+0.95724
$(-13l' - 13\lambda - \pi' - \omega)$	+0.10481	+1.20534	$(+6l' - 5\lambda - \omega)$	-0.06508	+0.93582
$(-12l' + 13\lambda - \pi' + \omega)$	-0.10201	+1.24054	$(+7l' - 6\lambda - \omega)$	+9.97692	+0.90067
$(-11l' - 11\lambda - \pi - \omega)$	+0.16646	+1.26770	$(+8l' - 7\lambda - \omega)$	+9.88312	+0.85582
$(-10l' - 10\lambda - \pi - \omega)$	+0.21979	+1.28490	$(+9l' - 8\lambda - \omega)$	+9.78621	+0.80252
$(-9l' - 9\lambda - \pi - \omega)$	+0.26775	+1.28974	$(+10l' - 9\lambda - \omega)$	+9.68661	+0.74262
$(-8l' - 8\lambda - \pi - \omega)$	+0.30586	+1.27846	$(+11l' - 10\lambda - \omega)$	+9.58485	+0.67725
$(-7l' - 7\lambda - \pi - \omega)$	+0.33099	+1.24521	$(+12l' - 11\lambda - \omega)$	+9.48128	+0.60731
$(-6l' - 6\lambda - \pi - \omega)$	+0.35423	+1.19935	$(+13l' - 12\lambda - \omega)$	+9.37621	+0.53345
$(-5l' - 5\lambda - \pi - \omega)$	+0.31908	+1.06082	$(+14l' - 13\lambda - \omega)$	+9.26987	+0.45625
$(-4l' - 4\lambda - \pi - \omega)$	+0.25649	+0.82859	$(+15l' - 14\lambda - \omega)$	+9.16240	+0.37608
$(-3l' + 3\lambda - \pi' + \omega)$	+0.10825	+0.02437	$(+16l' - 15\lambda - \omega)$	+9.05346	+0.29336
$(-2l' + 2\lambda - \pi' + \omega)$	+9.67090	-0.70045	$(+17l' - 16\lambda - \omega)$	+8.94448	+0.20832
$(-1l' + 1\lambda - \pi - \omega)$	+9.79882	-1.02424	$(+18l' - 17\lambda - \omega)$	+8.8325	+0.12140
$(-1l' - 1\lambda - \pi - \omega)$	-0.32618	-1.17715	$(+19l' - 18\lambda - \omega)$	+8.7193	+0.03041
$(+2l' - 2\lambda - \pi' + \omega)^\dagger$	+9.90635	-1.09348	$(+20l' - 19\lambda - \omega)$	+8.6128	+9.98669
$(+3l' - 3\lambda - \pi - \omega)$	+9.75072	-0.84535	$(+21l' - 20\lambda - \omega)$	+8.4914	+9.84991
$(+4l' - 4\lambda - \pi - \omega)$	+0.20803	-9.56584	$(+22l' - 21\lambda - \omega)$	+8.3802	+9.71742
$(+5l' - 5\lambda - \pi - \omega)$	+0.36239	+0.79665	$(+23l' - 22\lambda - \omega)$	+8.2787	+9.66298
$(+6l' - 6\lambda - \pi - \omega)$	+0.42800	+1.08243	$(+24l' - 23\lambda - \omega)$	+8.1461	+9.59450
$(+7l' - 7\lambda - \pi - \omega)$	+0.44929	+1.22312	$(+25l' - 24\lambda - \omega)$	+8.0414	+9.46982
$(+8l' - 8\lambda - \pi' + \omega)$	+0.44361	+1.30135	$(+26l' - 25\lambda - \omega)$	+7.9294	+9.36254
$(+9l' - 9\lambda - \pi - \omega)$	+0.41967	+1.34332	$(+27l' - 26\lambda - \omega)$	+7.7781	+9.27439
$(+10l' - 10\lambda - \pi' + \omega)$	+0.38249	+1.36107	$e' \eta^2 \cos (-5l' + 6\lambda - \pi')$	-9.5670	-1.64789
$(+11l' - 11\lambda - \pi' - \omega)$	-0.33524	+1.36129	$(-4l' + 5\lambda - \pi')$	-0.3363	-1.86721
$(+12l' - 12\lambda - \pi - \omega)$	+0.28013	+1.34813	$(-3l' + 4\lambda - \pi)$	-0.78866	-2.07463
$(+13l' - 13\lambda - \pi - \omega)$	+0.21862	+1.32438	$(-2l' + 3\lambda - \pi)$	-1.03902	-2.22085
$(+14l' - 14\lambda - \pi - \omega)$	+0.15180	+1.29195	$(-1l' + 2\lambda - \pi)$	-1.23690	-2.34916
$(+15l' - 15\lambda - \pi' + \omega)$	+0.08066	+1.25240	$(0 - 1\lambda - \pi)$	-1.40534	-2.45372
$(+16l' - 16\lambda - \pi - \omega)$	-0.00568	+1.20663	$(+1l' - 0 - \pi)$	-1.53534	-2.53806
$(+17l' - 17\lambda - \pi - \omega)$	+9.92612	+1.15582	$(+2l' - 1\lambda - \pi)^\S$	-1.62371	-2.60488
$(+18l' - 18\lambda - \pi - \omega)$	+9.84639	+1.10013	$(+3l' - 2\lambda - \pi)$	-1.68741	-2.65296
$(+19l' - 19\lambda - \pi' + \omega)$	+9.76262	+1.04123	$(+4l' - 3\lambda - \pi)$	-1.6743	-2.68365
$(+20l' - 20\lambda - \pi' + \omega)$	+9.67673	+0.97754	$(+5l' - 4\lambda - \pi)$	-1.66951	-2.70698
$e \cos (-21l' - 22\lambda - \omega)$	+8.00000	+9.33183	$(+6l' - 5\lambda - \pi)$	-1.63782	-2.69873
$(-20l' + 21\lambda - \omega)$	+8.07918	+9.41963	$(+7l' - 6\lambda - \pi)$	-1.60461	-2.69293
$(-19l' + 20\lambda - \omega)$	+8.20412	+9.50799	$(+8l' - 7\lambda - \pi)$	-1.55090	-2.67025
$(-18l' + 19\lambda - \omega)$	+8.31397	+9.59306	$(+9l' - 8\lambda - \pi)$	-1.50213	-2.64392
$(-17l' + 18\lambda - \omega)$	+8.42325	+9.67688	$(+10l' - 9\lambda - \pi)$	-1.44059	-2.61200
$(-16l' + 17\lambda - \omega)$	+8.53020	+9.75747	$(+11l' - 10\lambda - \pi')$	-1.37392	-2.56806
			$(+12l' - 11\lambda - \pi')$	-1.30085	-2.52496

	$a R_1$	$a a \frac{dR_1}{da}$		$a R_1$	$a a \frac{dR_1}{da}$
$* \eta^2 \cos 1^\circ \lambda$	-0.87815	-1.76651	$\S e \cos (-1l' - \omega)$	-9.92772	-9.82875
$\dagger e \cos (-2l' - 2\lambda - \pi - \omega)$	-0.19321	-1.11913	$\S e \eta^2 \cos (2l' - \lambda - \pi)$	-1.66565	-2.66625
$\ddagger e \cos (-1l' - 1\lambda - \omega)$	-9.50312	-0.59927			

TABLE IV—continued

	$a R_1$	$a a \frac{dR_1}{da}$		$a' R_1$	$a a' \frac{dR_1}{da}$
	-0.8880	-1.56745	$e' \eta^2 \cos (-5l' + 6\lambda - \pi' - 2r')$	+1.29596	+2.40281
$(-4l' + 3\lambda - \pi' + 2w)$	-0.06800	-0.06800	$(-4l' + 5\lambda - \pi' - 2r')$	-1.31680	-2.35763
$(-4l' + 3\lambda - \pi' + 2w)$	-0.30201	-1.14196	$(-3l' + 4\lambda - \pi' - 2r')$	-1.31943	-2.33646
$(-4l' + 3\lambda - \pi' + 2w)$	+9.92231	+1.63487	$(-2l' + 3\lambda - \pi' - 2r')$	-1.29627	-2.29751
$(-4l' + 3\lambda - \pi' + 2w)$	-0.44722	-1.57314	$(-l' + 2\lambda - \pi' - 2r')$	-1.23431	-2.23702
$(-4l' + 3\lambda - \pi' + 2w)$	-0.50272	-1.59499	$(-l' + \lambda - \pi' - 2r')$	-1.11194	-2.15580
$(-4l' + 3\lambda - \pi' + 2w)$	-0.37640	-1.44892	$(-l' + \lambda - \pi' - 2r')$	-0.93827	-2.05007
$(-4l' + 3\lambda - \pi' + 2w)$	-0.25082	-1.31174	$(-2l' + \lambda - \pi' - 2r')$	-0.71600	-1.92361
$(-4l' + 3\lambda - \pi' + 2w)$	-0.30062	-1.28852	$(-3l' + \lambda - \pi' - 2r')$	-0.41280	-1.76133
$(-4l' + 3\lambda - \pi' + 2w)$	-0.46735	-1.20702	$(-4l' + \lambda - \pi' - 2r')$	-9.869	-1.49128
$(-4l' + 3\lambda - \pi' + 2w)$	-0.59298	-1.30750	$(-5l' + \lambda - \pi' - 2r')$	-9.695	-0.50284
$(-4l' + 3\lambda - \pi' + 2w)$	-0.67669	-1.43470			
$(-4l' + 3\lambda - \pi' + 2w)$	-0.73775	-1.55163	$e^2 \cos (-15l' + 17\lambda - 2w)$	+9.24027	+0.43503
$(-4l' + 3\lambda - \pi' + 2w)$	-0.77320	-1.64573	$(-14l' + 16\lambda - 2w)$	-9.31742	-0.48170
$(-4l' + 3\lambda - \pi' + 2w)$	-0.79085	.....	$(-13l' + 15\lambda - 2w)$	-9.39085	-0.52397
			$(-12l' + 14\lambda - 2w)$	-9.46382	-0.55912
$ee^2 \cos (-3l' + 4\lambda - 2\pi' + w)$	-0.27007	-1.85450	$(-11l' + 13\lambda - 2w)$	-9.52625	-0.58718
$(-2l' + 3\lambda - 2\pi' + w)$	-0.27183	-1.33136	$(-10l' + 12\lambda - 2w)$	-9.58652	-0.60623
$(-l' + 2\lambda - 2\pi' + w)$	-0.34415	-1.43722	$(-9l' + 11\lambda - 2w)$	-9.64061	-0.61491
$(-l' + 2\lambda - 2\pi' + w)$	-0.45892	-1.60499	$(-8l' + 10\lambda - 2w)$	-9.68729	-0.61095
$(-l' + 2\lambda - 2\pi' + w)$	-0.67435	-1.66780	$(-7l' + 9\lambda - 2w)$	-9.72481	-0.59171
$(-2l' + \lambda - 2\pi' + w)$	-0.76026	-1.73583	$(-6l' + 8\lambda - 2w)$	-9.75101	-0.55413
$(-3l' + \lambda - 2\pi' + w)$	-0.63517	-1.74196	$(-5l' + 7\lambda - 2w)$	-9.76288	-0.49529
$(-4l' + 3\lambda - 2\pi' + w)$	-9.84466	-1.64784	$(-4l' + 6\lambda - 2w)$	-9.75465	-0.41556
$(-4l' + 3\lambda - 2\pi' + w)$	-1.33764	-1.33764	$(-3l' + 5\lambda - 2w)$	-9.72982	-0.32907
$(-4l' + 3\lambda - 2\pi' + w)$	-0.92130	-1.00639	$(-2l' + 4\lambda - 2w)$	-9.67070	-0.28771
$(-4l' + 3\lambda - 2\pi' + w)$	-1.08505	-1.67554	$(-l' + 3\lambda - 2w)$	-9.59754	-0.37614
$(-4l' + 3\lambda - 2\pi' + w)$	-1.18222	-1.90278	$(-l' + 2\lambda - 2w)$	-9.52883	-0.60222
$(-4l' + 3\lambda - 2\pi' + w)$	-1.23636	-2.08651	$(-l' + \lambda - 2w)$	-0.01641	-0.80005
$(-4l' + 3\lambda - 2\pi' + w)$	-1.26588	-2.18250	$(-2l' + \lambda - 2w)$	-0.40522	-1.12207
$(-4l' + 3\lambda - 2\pi' + w)$	-1.27442	-2.25244	$(-3l' + \lambda - 2w)$	-0.57404	-1.31007
$(-4l' + 3\lambda - 2\pi' + w)$	-1.30750	-2.29465	$(-4l' + \lambda - 2w)$	-0.65307	-1.43861
$(-4l' + 3\lambda - 2\pi' + w)$	-1.2923	-2.3124	$(-5l' + \lambda - 2w)$	-0.68475	-1.52567
$(-4l' + 3\lambda - 2\pi' + w)$	-1.2624	-2.3302	$(-6l' + \lambda - 2w)$	-0.68708	-1.58014
$(-4l' + 3\lambda - 2\pi' + w)$	-1.2253	-2.3248	$(-7l' + \lambda - 2w)$	-0.66940	-1.61081
$(-4l' + 3\lambda - 2\pi' + w)$	-1.1861	-2.3193	$(-8l' + \lambda - 2w)$	-0.63725	-1.62313
$(-4l' + 3\lambda - 2\pi' + w)$	-1.1400	-2.2944	$(-9l' + \lambda - 2w)$	-0.59411	-1.62061
$(-4l' + 3\lambda - 2\pi' + w)$	-1.0864	-2.2695	$(-10l' + \lambda - 2w)$	-0.54238	-1.60092
$(-4l' + 3\lambda - 2\pi' + w)$	-1.0294	.....	$(-11l' + \lambda - 2w)$	-0.48375	-1.58323
$(-4l' + 3\lambda - 2\pi' + w)$	-0.9689	.....	$(-12l' + \lambda - 2w)$	-0.41942	-1.57516
			$(-13l' + 11\lambda - 2w)$	-0.35033	-1.51267
			$(-14l' + 12\lambda - 2w)$	-0.27722	-1.46801
			$(-15l' + 13\lambda - 2w)$	-0.20117	-1.41817
$e^4 \cos (6l' - 4\lambda - 2w)$	-1.12189	.....			
$e^2 e'^2 \cos (6l' - 4\lambda - 2w)$	-1.96412	.....			
$e^2 \eta^2 \cos (6l' - 4\lambda - 2w)$	-2.37355	.....			
$ee' \cos (-13l' + 15\lambda - \pi' + w)$	-9.45461	-0.60219			
$(-12l' + 14\lambda - \pi' + w)$	-9.52409	-0.60800			
$(-11l' + 13\lambda - \pi' + w)$	-9.59232	-0.72546			
$(-10l' + 12\lambda - \pi' + w)$	-9.65343	-0.75263			
$(-9l' + 11\lambda - \pi' + w)$	-9.71070	-0.77237			
$(-8l' + 10\lambda - \pi' + w)$	-9.76296	-0.78155			
$(-7l' + 9\lambda - \pi' + w)$	-9.80168	-0.77921			
$(-6l' + 8\lambda - \pi' + w)$	-9.83322	-0.76337			
$(-5l' + 7\lambda - \pi' + w)$	-9.85763	-0.73261			
$(-4l' + 6\lambda - \pi' + w)$	-9.87499	-0.68749			
$(-3l' + 5\lambda - \pi' + w)$	-9.88452	-0.63481			
$(-2l' + 4\lambda - \pi' + w)$	-9.88730	-0.60033			

TABLE IV (continued)

	$a R_1$	$a \frac{dR_1}{da}$		$a' R_1$	$a' \frac{dR_1}{da}$
$ee' \cos (-2l' + 4\lambda - \pi + \omega)$	-9.78599	-0.61951	$e'^2 \cos (+13l' - 11\lambda - 2\pi')$	+0.56873	+1.67392
$(-1l' + 3\lambda - \pi + \omega)$	-9.80319	-0.74161	$(+14l' - 12\lambda - 2\pi')$	+0.50405	+1.63504
$(+2l' - \pi + \omega)$	-9.96440	-0.94535	$(+15l' - 13\lambda - 2\pi')$	-0.42870	+1.59026
$(+1l' + 1\lambda - \pi + \omega)^*$	-0.32618	-1.17716	$(+16l' - 14\lambda - 2\pi')$	+0.32885	+1.54035
$(+2l' - \pi - \omega)$	-0.76116	-1.40475	$(+17l' - 15\lambda - 2\pi')$	+0.26891	+1.48593
$(+3l' - 1\lambda - \pi - \omega)$	-0.95270	-1.60877	$(+18l' - 16\lambda - 2\pi')$	+0.18518	.....
$(+1l' - 2\lambda - \pi - \omega)$	-1.04356	-1.75595	$(+19l' - 17\lambda - 2\pi')$	+0.09914	.....
$(+5l' - 3\lambda - \pi - \omega)$	-1.08220	-1.85722	$(+20l' - 18\lambda - 2\pi')$	+0.01641	.....
$(+6l' - 4\lambda - \pi + \omega)$	-1.08907	-1.92308	$(+21l' - 19\lambda - 2\pi')$	+9.92174	.....
$(+7l' - 5\lambda - \pi + \omega)$	-1.07461	-1.96385	$(+22l' - 20\lambda - 2\pi')$	+9.828	.....
$(+8l' - 6\lambda - \pi + \omega)$	-1.04473	-1.98376	$(+23l' - 21\lambda - 2\pi')$	+9.736	.....
$(+9l' - 7\lambda - \pi + \omega)$	-1.00354	-1.98771	$(+24l' - 22\lambda - 2\pi')$	+9.642	.....
$(+10l' - 8\lambda - \pi + \omega)$	-0.95327	-1.97885	$(+25l' - 23\lambda - 2\pi')$	+9.549	.....
$(+11l' - 9\lambda - \pi + \omega)$	-0.89581	-1.95949			
$(+12l' - 10\lambda - \pi + \omega)$	-0.83247	-1.93127	$e'^2 \cos (6l' - 4\lambda - 2\pi')$	-1.43088	
$(+13l' - 11\lambda - \pi + \omega)$	-0.76422	-1.89567			
$(+14l' - 12\lambda - \pi + \omega)$	-0.69179	-1.84138	$e'^4 \cos (6l' - 4\lambda - 2\pi')$	-1.38917	
$(+15l' - 13\lambda - \pi + \omega)$	-0.61583	-1.80627			
$(+16l' - 14\lambda - \pi + \omega)$	-0.53674	-1.75403	$e'^2 \eta^2 \cos (6l' - 4\lambda - 2\pi')$	-2.41885	
$(+17l' - 15\lambda - \pi + \omega)$	-0.45500	.....			
$(+18l' - 16\lambda - \pi + \omega)$	-0.37162	.....	$ee'^3 \cos (6l' - 4\lambda - 2\pi')$	+0.61278	
$(+19l' - 17\lambda - \pi + \omega)$	-0.28443	.....			
$(+20l' - 18\lambda - \pi + \omega)$	-0.19590	.....	$\eta^2 \cos (-9l' + 11\lambda - 2\pi')$	+9.80482	+0.98963
$(+21l' - 19\lambda - \pi + \omega)$	-0.10619	.....	$(-8l' + 10\lambda - 2\pi')$	+9.90875	+1.06556
$(+22l' - 20\lambda - \pi + \omega)$	-0.01410	.....	$(-7l' + 9\lambda - 2\pi')$	+0.01207	+1.13965
$(+23l' - 21\lambda - \pi + \omega)$	-9.92169	.....	$(-6l' + 8\lambda - 2\pi')$	+0.11295	+1.20649
$(+24l' - 22\lambda - \pi + \omega)$	-9.82802	.....	$(-5l' + 7\lambda - 2\pi')$	+0.21128	+1.26022
$(+25l' - 23\lambda - \pi + \omega)$	-9.73320	.....	$(-4l' + 6\lambda - 2\pi')$	+0.30652	+1.32837
			$(-3l' + 5\lambda - 2\pi')$	+0.39791	+1.37988
$e^2 e' \cos (6l' - 4\lambda - \pi' - \omega)$	+1.55169		$(-2l' + 4\lambda - 2\pi')$	+0.48377	+1.42334
			$(-1l' + 3\lambda - 2\pi')$	+0.56176	+1.45683
$ee' \cos (6l' - 4\lambda - \pi - \omega)$	+1.90298		$(+2\lambda - 2\pi')$	+0.62721	+1.47818
			$(+1l' + 1\lambda - 2\pi')^{\dagger}$	+0.66859	+1.48493
$ee' \eta^2 \cos (6l' - 4\lambda - \pi' - \omega)$	+2.67076		$(+2l' - 2\pi')$	+0.62721	+1.47818
			$(+3l' - 1\lambda - 2\pi')$	+0.56176	+1.45683
$e'^2 \cos (-13l' + 15\lambda - 2\pi')$	+9.05721	+0.25209	$(+4l' - 2\lambda - 2\pi')$	+0.48377	+1.42331
$(-12l' + 14\lambda - 2\pi')$	+9.12087	+0.28538	$(+5l' - 3\lambda - 2\pi')$	+0.39791	+1.37988
$(-11l' + 13\lambda - 2\pi')$	+9.17921	+0.31322	$(+6l' - 4\lambda - 2\pi')$	+0.30652	+1.32837
$(-10l' + 12\lambda - 2\pi')$	+9.23160	+0.33160	$(+7l' - 5\lambda - 2\pi')$	+0.21128	+1.26022
$(-9l' + 11\lambda - 2\pi')$	+9.27674	+0.34096	$(+8l' - 6\lambda - 2\pi')$	+0.11295	+1.20649
$(-8l' + 10\lambda - 2\pi')$	+9.31260	+0.33905	$(+9l' - 7\lambda - 2\pi')$	+0.01207	+1.13965
$(-7l' + 9\lambda - 2\pi')$	+9.33832	+0.32542	$(+10l' - 8\lambda - 2\pi')$	+9.90875	+1.06556
$(-6l' + 8\lambda - 2\pi')$	+9.35170	+0.29997	$(+11l' - 9\lambda - 2\pi')$	+9.80482	+0.98963
$(-5l' + 7\lambda - 2\pi')$	+9.35120	+0.26624			
$(-4l' + 6\lambda - 2\pi')$	+9.33760	+0.23602	$e^2 \eta^2 \cos (6l' - 4\lambda - 2\pi')$	+1.60097	
$(-3l' + 5\lambda - 2\pi')$	+9.31988	+0.23562			
$(-2l' + 4\lambda - 2\pi')$	+9.32919	+0.30124	$e'^2 \eta^2 \cos (6l' - 4\lambda - 2\pi')$	-9.77815	
$(-1l' + 3\lambda - 2\pi')$	+0.42933	+0.44797			
$(-2\lambda - 2\pi')$	+0.66761	+0.65018	$\eta^4 \cos (6l' - 4\lambda - 2\pi')$	-1.8902	
$(+1l' + 1\lambda - 2\pi')^{\dagger}$	+0.01535	+0.86905			
$(+2l' - 2\pi')$	+0.47741	+1.07029	$e^3 \cos (-4l' + 7\lambda - 3\omega)$	+9.8553	+0.40115
$(+3l' - 1\lambda - 2\pi')^{\dagger}$	+0.71910	+1.28134	$(-3l' + 6\lambda - 3\omega)$	+9.7528	+9.98511
$(+4l' - 2\lambda - 2\pi')$	+0.82723	+1.45132	$(-2l' + 5\lambda - 3\omega)$	+9.5688	+9.72835
$(+5l' - 3\lambda - 2\pi')$	+0.87482	+1.57246	$(-1l' + 4\lambda - 3\omega)^{\S}$	+8.91434	+0.36710
$(+6l' - 4\lambda - 2\pi')$	+0.88721	+1.65437	$(-3\lambda - 3\omega)$	+9.47553	-0.65861
$(+7l' - 5\lambda - 2\pi')$	+0.87649	+1.70646	$(+1l' + 2\lambda - 3\omega)^{*\dagger}$	-9.76373	-0.91747
$(+8l' - 6\lambda - 2\pi')$	+0.84943	+1.73492	$(+2l' + 1\lambda - 3\omega)$	-0.19564	-1.19371
$(+9l' - 7\lambda - 2\pi')$	+0.81018	+1.74713	$(+3l' - 3\omega)$	-0.57471	-1.45904
$(+10l' - 8\lambda - 2\pi')$	+0.76153	+1.74431	$(+4l' - 1\lambda - 3\omega)$	-0.81489	-1.68553
$(+11l' - 9\lambda - 2\pi')$	+0.70536	+1.72992	$(+5l' - 2\lambda - 3\omega)$	-0.96891	-1.86215
$(+12l' - 10\lambda - 2\pi')$	+0.64307	+1.70594	$(+6l' - 3\lambda - 3\omega)$	-1.06842	-1.99642
			$(+7l' - 4\lambda - 3\omega)$	-1.13096	-2.09720

	$a R_1$	$a \frac{dR_1}{da}$		$a' R_1$	$a' \frac{dR_1}{da}$
$* e' \cos (l' - \lambda - \pi - \omega)$	-0.74492	-1.36718	$* e' \cos (l' - \lambda - 2\pi)$	+0.39984	+1.47405
$^{\dagger} e^2 \cos (l' + \lambda - 2\pi)$	+0.22418	+0.86517	$^{\S} e' \cos (l' - 1/2 \lambda - 3\omega)$	-0.22574	-0.41183
$^{\ddagger} e' \cos (3l' - \lambda - 2\pi)$	+0.43000	+1.21926	$^{**} e' \cos (l' - 2\lambda - 3\omega)$	-0.78665	-0.91912

TABLE IV - Continued

	$a R_1$	$a \frac{dR_1}{da}$		$a R_1$	$a \frac{dR_1}{da}$
$\epsilon \cos (-5' - 2\lambda - \omega)$	-1.16689	-2.15963	$\epsilon \cos (-11' + 2\lambda - \omega)$	+1.32789	+2.40601
$\epsilon \cos (-10' - 7\lambda - 3\omega)$	-1.22853	-2.22382	$\epsilon \cos (-11' + 1\lambda - \omega)$	+1.47807	+2.49862
$\epsilon \cos (-11' - 8\lambda - 3\omega)$	-1.18224	-2.25182	$\epsilon \cos (-11' - \omega)$	+1.57859	+2.57175
$\epsilon \cos (-12' - 9\lambda - 3\omega)$	-1.16615	-2.27985	$\epsilon \cos (-2' - 1\lambda - \omega)$	+1.66789	+2.62475
	-1.14907	.....	$\epsilon \cos (-3' - 2\lambda - \omega)$	+1.64068	+2.66011
$\epsilon \cos (-9' + 10\lambda - \omega)$	-0.74554	.....	$\epsilon \cos (-4' - 3\lambda - \omega)$	+1.64527	+2.67877
$\epsilon \cos (-8' + 9\lambda - \omega)$	-0.73087	-0.71249	$\epsilon \cos (-5' - 4\lambda - \omega)$	+1.61669	+2.67981
$\epsilon \cos (-7' - 8\lambda - \omega)$	-0.96521	-1.58387	$\epsilon \cos (-6' - 5\lambda - \omega)$	+1.58686	+2.67615
$\epsilon \cos (-6' - 7\lambda - \omega)$	-0.96521	-1.48655	$\epsilon \cos (-7' - 6\lambda - \omega)$	+1.53407	+2.65498
$\epsilon \cos (-5' + 6\lambda - \omega)$	-0.59757	-0.49870	$\epsilon \cos (-8' - 7\lambda - \omega)$	+1.48746	+2.63004
$\epsilon \cos (-4' - 5\lambda - \omega)$	-0.37293	-1.25081	$\epsilon \cos (-9' - 8\lambda - \omega)$	+1.42730	+2.59940
$\epsilon \cos (-3' - 4\lambda - \omega)$	-0.25876	-1.19089	$\epsilon \cos (-10' - 9\lambda - \omega)$	+1.36171	+2.55630
$\epsilon \cos (-2' + 3\lambda - \omega)$	-0.25531	-1.23550	$\epsilon \cos (-11' - 10\lambda - \omega)$	+1.29159	+2.51412
$\epsilon \cos (-1' + 2\lambda - \omega)$	-0.1632	-1.36303	$\epsilon \cos (-12' - 11\lambda - \omega)$	+1.21759	+2.46377
$\epsilon \cos (0' + 1\lambda - \omega)$	-0.1632	-1.49739			
$\epsilon \cos (+1' - 0' - \omega)$	-0.55374	-1.58743	$\epsilon \cos (-20' + 21\lambda - \pi)$	-7.954	-9.3090
$\epsilon \cos (+2' - 1\lambda - \omega)$	-0.46545	-1.60121	$\epsilon \cos (-19' + 20\lambda - \pi)$	-8.0792	-9.3855
$\epsilon \cos (+3' - 2\lambda - \omega)$	-0.84061	-1.49760	$\epsilon \cos (-18' + 19\lambda - \pi)$	-8.1760	-9.4824
$\epsilon \cos (+4' - 3\lambda - \omega)$	+0.36700	-1.13464	$\epsilon \cos (-17' + 18\lambda - \pi)$	-8.2900	-9.5658
$\epsilon \cos (+5' - 4\lambda - \omega)$	+0.73745	+1.04552	$\epsilon \cos (-16' + 17\lambda - \pi)$	-8.3979	-9.6478
$\epsilon \cos (+6' - 5\lambda - \omega)$	+0.91761	+1.24087	$\epsilon \cos (-15' + 16\lambda - \pi)$	-8.4983	-9.7262
$\epsilon \cos (+7' - 6\lambda - \omega)$	+1.01983	+1.84233	$\epsilon \cos (-14' + 15\lambda - \pi)$	-8.60338	-9.8021
$\epsilon \cos (+8' - 7\lambda - \omega)$	+1.08200	.....	$\epsilon \cos (-13' + 14\lambda - \pi)$	-8.70483	-9.7387
$\epsilon \cos (+9' - 8\lambda - \omega)$	+1.11383	.....	$\epsilon \cos (-12' + 13\lambda - \pi)$	-8.80405	-9.9413
$\epsilon \cos (+10' - 9\lambda - \omega)$	+1.17909	.....	$\epsilon \cos (-11' + 12\lambda - \pi)$	-8.90087	-0.0034
$\epsilon \cos (+11' - 10\lambda - \omega)$	+1.17387	.....	$\epsilon \cos (-10' + 11\lambda - \pi)$	-8.99677	-0.0588
$\epsilon \cos (+12' - 11\lambda - \omega)$	+1.15698	.....	$\epsilon \cos (-9' + 10\lambda - \pi)$	-9.08426	-0.1061
			$\epsilon \cos (-8' + 9\lambda - \pi)$	-9.16892	-0.1427
$\epsilon \cos (-9' + 10\lambda - \omega)$	+0.97630	-1.95796	$\epsilon \cos (-7' + 8\lambda - \pi)$	-9.24673	-0.16485
$\epsilon \cos (-8' + 9\lambda - \omega)$	+0.96215	-1.89546	$\epsilon \cos (-6' + 7\lambda - \pi)$	-9.31486	-0.16624
$\epsilon \cos (-7' + 8\lambda - \omega)$	+0.92609	-1.82367	$\epsilon \cos (-5' + 6\lambda - \pi)$	-9.36881	-0.13494
$\epsilon \cos (-6' + 7\lambda - \omega)$	+0.88947	-1.73521	$\epsilon \cos (-4' + 5\lambda - \pi)$	-9.39914	-0.04347
$\epsilon \cos (-5' + 6\lambda - \omega)$	+0.81325	-1.64523	$\epsilon \cos (-3' + 4\lambda - \pi)$	-9.38463	-9.79691
$\epsilon \cos (-4' + 5\lambda - \omega)$	+0.72779	-1.58470	$\epsilon \cos (-2' + 3\lambda - \pi)$	-9.25513	+9.15297
$\epsilon \cos (-3' + 4\lambda - \omega)$	+0.65040	-1.59260	$\epsilon \cos (-1' + 2\lambda - \pi)$	-7.22194	+0.10195
$\epsilon \cos (-2' + 3\lambda - \omega)$	+0.63759	-1.67586	$\epsilon \cos (0' + 1\lambda - \pi)$	+9.65167	+0.43914
$\epsilon \cos (-1' + 2\lambda - \omega)$	+0.72955	-1.73520	$\epsilon \cos (-1' - \pi)$	+0.28833	+0.62721
$\epsilon \cos (0' + 1\lambda - \omega)$	+0.87612	-1.89643	$\epsilon \cos (-2' - 1\lambda - \pi)^{+}$	+0.39478	+0.81795
$\epsilon \cos (+1' - 0' - \omega)$	+0.90274	-1.94869	$\epsilon \cos (-3' - 2\lambda - \pi)$	+0.36881	+0.92452
$\epsilon \cos (+2' - 1\lambda - \omega)$	+0.64935	-1.91679	$\epsilon \cos (-4' - 3\lambda - \pi)$	+0.32460	+0.97499
$\epsilon \cos (+3' - 2\lambda - \omega)$	+0.25003	-1.74228	$\epsilon \cos (-5' - 4\lambda - \pi)$	+0.25489	+0.99035
$\epsilon \cos (+4' - 3\lambda - \omega)$	+0.95436	-0.96182	$\epsilon \cos (-6' - 5\lambda - \pi)$	+0.17480	+0.98215
$\epsilon \cos (+5' - 4\lambda - \omega)$	+1.20194	+1.65287	$\epsilon \cos (-7' - 6\lambda - \pi)$	+0.08779	+0.95716
$\epsilon \cos (+6' - 5\lambda - \omega)$	+1.33746	+2.00660	$\epsilon \cos (-8' - 7\lambda - \pi)$	+9.99578	+0.91962
$\epsilon \cos (+7' - 6\lambda - \omega)$	+1.41716	+2.25373	$\epsilon \cos (-9' - 8\lambda - \pi)$	+9.90043	+0.87237
$\epsilon \cos (+8' - 7\lambda - \omega)$	+1.46228	+2.37566	$\epsilon \cos (-10' - 9\lambda - \pi)$	+9.80135	+0.8174
$\epsilon \cos (+9' - 8\lambda - \omega)$	+1.48328	+2.45773	$\epsilon \cos (-11' - 10\lambda - \pi)$	+9.70031	+0.7561
$\epsilon \cos (+10' - 9\lambda - \omega)$	+1.48712	+2.51095	$\epsilon \cos (-12' - 11\lambda - \pi)$	+9.59737	+0.6896
$\epsilon \cos (+11' - 10\lambda - \omega)$	+1.47712	+2.54469	$\epsilon \cos (-13' - 12\lambda - \pi)$	+9.49280	+0.6187
$\epsilon \cos (+12' - 11\lambda - \omega)$	+1.447	+2.56194	$\epsilon \cos (-14' - 13\lambda - \pi)$	+9.38687	+0.5440
$\epsilon \cos (+13' - 12\lambda - \omega)$	+1.416	+2.56738	$\epsilon \cos (-15' - 14\lambda - \pi)$	+9.27977	+0.4621
$\epsilon \cos (+14' - 13\lambda - \omega)$	+1.382	+2.56573	$\epsilon \cos (-16' - 15\lambda - \pi)$	+9.17169	+0.3853
$\epsilon \cos (+15' - 14\lambda - \omega)$	+1.347	+2.5315	$\epsilon \cos (-17' - 16\lambda - \pi)$	+9.06070	+0.3021
$\epsilon \cos (+16' - 15\lambda - \omega)$	+1.307	.....	$\epsilon \cos (-18' - 17\lambda - \pi)$	+8.95284	+0.2167
$\epsilon \cos (+17' - 16\lambda - \omega)$	+1.253	.....	$\epsilon \cos (-19' - 18\lambda - \pi)$	+8.84198	+0.1290
$\epsilon \cos (+18' - 17\lambda - \omega)$	+1.190	.....	$\epsilon \cos (-20' - 19\lambda - \pi)$	+8.73102	+0.0378
$\epsilon \cos (+19' - 18\lambda - \omega)$	+1.113	.....	$\epsilon \cos (-21' - 20\lambda - \pi)$	+8.6180	+9.9489
			$\epsilon \cos (-22' - 21\lambda - \pi)$	+8.5071	+9.8567
$\epsilon \cos (-5' + 6\lambda - \omega)$	+0.92531	+1.71851	$\epsilon \cos (-23' - 22\lambda - \pi)$	+8.3892	+9.7634
$\epsilon \cos (-4' + 5\lambda - \omega)$	+0.59755	+1.97703	$\epsilon \cos (-24' - 23\lambda - \pi)$	+8.2814	+9.6676
$\epsilon \cos (-3' + 4\lambda - \omega)$	+0.89581	+2.15084	$\epsilon \cos (-25' - 24\lambda - \pi)$	+8.1654	+9.6002
$\epsilon \cos (-2' + 3\lambda - \omega)$	+1.13714	+2.29038	$\epsilon \cos (-26' - 25\lambda - \pi)$	+8.0538	+9.4756

	$a R_{01}$	$a \frac{dR_{01}}{da}$		$a R_{01}$	$a \frac{dR_{01}}{da}$
$\epsilon \cos (-1' - 2\lambda - \omega)$	-0.18435	-1.35965	$\epsilon \cos (-1' + 2\lambda - \omega)$	+1.35744	+2.40685
$\epsilon \cos (-1' - \omega)$	-0.17989	-1.73989	$\epsilon \cos (-1' - \omega)$	+1.50343	+2.50343
$\epsilon \cos (-2' - \lambda - \omega)$	-0.56211	-1.93444	$\epsilon \cos (-2' - \lambda - \omega)$	+0.98823	+0.7047

TABLE IV—*Continued*

	$a' R_1$	$a' a \frac{dR_1}{da}$		$a' R_1$	$a' a \frac{dR_1}{da}$
$e^2 e' \cos (-7l' + 8\lambda - \pi')$	+0.90217	.....	$(-2l' + 3\lambda - \pi')$	+0.33417	+1.40159
$(-6l' + 7\lambda - \pi')$	+0.86457	+1.76226	$(-1l' + 2\lambda - \pi')$	+0.44469	+1.51683
$(-5l' + 6\lambda - \pi')$	+0.80557	+1.67484	$(-1l' + \lambda - \pi')$	+0.60576	+1.62587
$(-4l' + 5\lambda - \pi')$	+0.73111	+1.60148	$(+1l' - \pi')$	+0.70807	+1.70018
$(-3l' + 4\lambda - \pi')$	+0.64802	+1.57523	$(+2l' - \lambda - \pi')$ †	+0.60160	+1.71297
$(-2l' + 3\lambda - \pi')$	+0.59662	+1.60714	$(+3l' - 2\lambda - \pi')$	+9.88412	+1.62638
$(-1l' + 2\lambda - \pi')$	+0.63801	+1.84224	$(+4l' - 3\lambda - \pi')$	-0.53788	+1.32931
$(-1l' + \lambda - \pi')$	+0.77974	+1.83856	$(+5l' - 4\lambda - \pi')$	-0.89185	-0.94718
$(+1l' - \pi')$	+0.92443	+1.93802	$(+6l' - 5\lambda - \pi')$	-1.06225	-1.64883
$(+2l' - \lambda - \pi')$ *	+0.93706	+1.97961	$(+7l' - 6\lambda - \pi')$	-1.16523	-1.91255
$(+3l' + 2\lambda - \pi')$	+0.65094	+1.93932	$(+8l' - 7\lambda - \pi')$	-1.22011	-2.06915
$(+4l' + 3\lambda - \pi')$ †	-0.36158	+1.75312	$(+9l' - 8\lambda - \pi')$	-1.25005	-2.17036
$(+5l' + 4\lambda - \pi')$	-0.99561	+0.86503	$(+10l' - 9\lambda - \pi')$	-1.26035	-2.25523
$(+6l' + 5\lambda - \pi')$	-1.23150	-1.73756	$(+11l' - 10\lambda - \pi')$	-1.2658	-2.28193
$(+7l' + 6\lambda - \pi')$	-1.36124	-1.08641	$(+12l' - 11\lambda - \pi')$	-1.2778	-2.3006
$(+8l' + 7\lambda - \pi')$	-1.43727	-1.38807	$(+13l' - 12\lambda - \pi')$	-1.2526	-2.3194
$(+9l' + 8\lambda - \pi')$	-1.47979	.....	$(+14l' - 13\lambda - \pi')$	-1.2205	-2.3142
$(+10l' + 9\lambda - \pi')$	-1.51569	.....	$(+15l' - 14\lambda - \pi')$	-1.1807	.....
$e'^3 \cos (-7l' + 8\lambda - \pi')$	+0.51348	.....	$(+16l' - 15\lambda - \pi')$	-1.1513	-2.3069
$(-6l' + 7\lambda - \pi')$	+0.47012	+1.39838	$(+17l' - 16\lambda - \pi')$	-1.0785	-2.2790
$(-5l' + 6\lambda - \pi')$	+0.41162	+1.33270	$(+18l' - 17\lambda - \pi')$	-1.0213	-2.2624
$(-4l' + 5\lambda - \pi')$	+0.34713	+1.29632	$(+19l' - 18\lambda - \pi')$	-0.9624	.....
$(-3l' + 4\lambda - \pi')$	+0.31190	+1.31836	$(+20l' - 19\lambda + \pi')$	-0.9017	.....

	$a' R_{01}$	$a' a \frac{dR_{01}}{da}$		$a' R_{01}$	$a' a \frac{dR_{01}}{da}$
$*e^2 e' \cos (2l' - \lambda - \pi')$	+0.97393	-1.98303	$†e^2 e' \cos (2l' - \lambda - \pi')$	-0.70888	-1.72297











